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**Residential Solar Hot-Water Heating
and Space Conditioning Systems in
Northern California: A Brief Survey**

B. A. Greene

August 1976

Lawrence Berkeley Laboratory University of California/Berkeley
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RESIDENTIAL SOLAR HOT WATER HEATING AND
SPACE CONDITIONING SYSTEMS IN NORTHERN
CALIFORNIA: A BRIEF SURVEY*

B. A. Greene
(assisted by P. Caesar and Y. Howell)

October 1976

* This report also appears as Appendix B of Electrical Energy Consumption in California: Data Collection and Analysis, Lawrence Berkeley Laboratory report UCID-3847, prepared for the California Energy Resources Conservation and Development Commission by the Conservation Assessment Group of the Lawrence Berkeley Laboratory.

RESIDENTIAL SOLAR HOT WATER HEATING AND
SPACE CONDITIONING SYSTEMS IN NORTHERN
CALIFORNIA: A BRIEF SURVEY

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ABSTRACT

Data are presented on approximately 60 residential solar energy systems located within the San Francisco Bay Area and Northern California regions. The systems, almost all built within the last 2 to 3 years, represent a wide spectrum of approaches to solar heating and cooling and solar hot-water heating. Data concern the building itself, the solar system, collector, storage system, and auxiliary (backup) system. Where possible, detailed information is included on the initial costs of the systems and on their performance to date.

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INTRODUCTION

The great variation in estimates of probable contribution of solar energy towards meeting California's energy needs is partially due to the lack of hard data. Within the residential sector, those data have been unavailable, simply because there were very few systems in operation in the state. Estimates had therefore to be made on the basis of intelligent guesswork – specifically as to the cost of solar heating/cooling/hot water heating systems, and the adequacy (performance) of such systems.

Some hard data are now available. Within the last two or three years, a (surprising) number of residential systems for solar heating, for solar heating and cooling, and/or for solar hot-water heating have been built within the state. This report presents data for approximately 60 systems located within the general Bay Area and Northern California region. Where possible, very detailed information is included on the initial costs of systems and their performance to date.

Almost all systems located had been built within the last two years. Systems in the sample represent a wide spectrum of the possible technologies and a wide spectrum of costs. It became evident during the period of this brief survey that a considerable evolution of the technology involved in solar space heating, space cooling, and hot-water heating for the residential sector has occurred, with resultant decreases in system costs.

Availability of Solar Energy in California

Available information on measurements of solar radiation in California (insolation data) has been compiled by the Department of Water Resources, Division of Resources Development, in their report Solar Radiation Measurements in California, January 1974 (see Fig. 1). Data are available for 55 stations, but vary in both quality and duration. Considerable additional information is now being collected.

For the purpose of design of a residential solar space heating/cooling/hot-water heating system, insolation and climatological data are of importance, both in sizing the system (collector and storage) and in the initial decision as to whether a system should be installed (probable payback period). Considerable research is now underway on

sizing of a system as a function of climate and available insolation, with direct application to specific areas of California. As these data become available, the initial decision on whether to install a system, and the subsequent decisions on the type and size of system to install can all be made more easily and with greater accuracy.

At present, very reasonable guesses can be made on system sizing on the basis of the existing climatological and insolation data, where measured data exist for a given location. Where a site is distant from any measuring station, extrapolation on the basis of climatological maps may provide reasonably accurate data, within an accuracy sufficient for system sizing. Such climatological maps (see, for example, Sunset Garden Book climate zone map for the general Bay Area) are of particular use along the coastal regions of California, where fog patterns are accurately delineated.

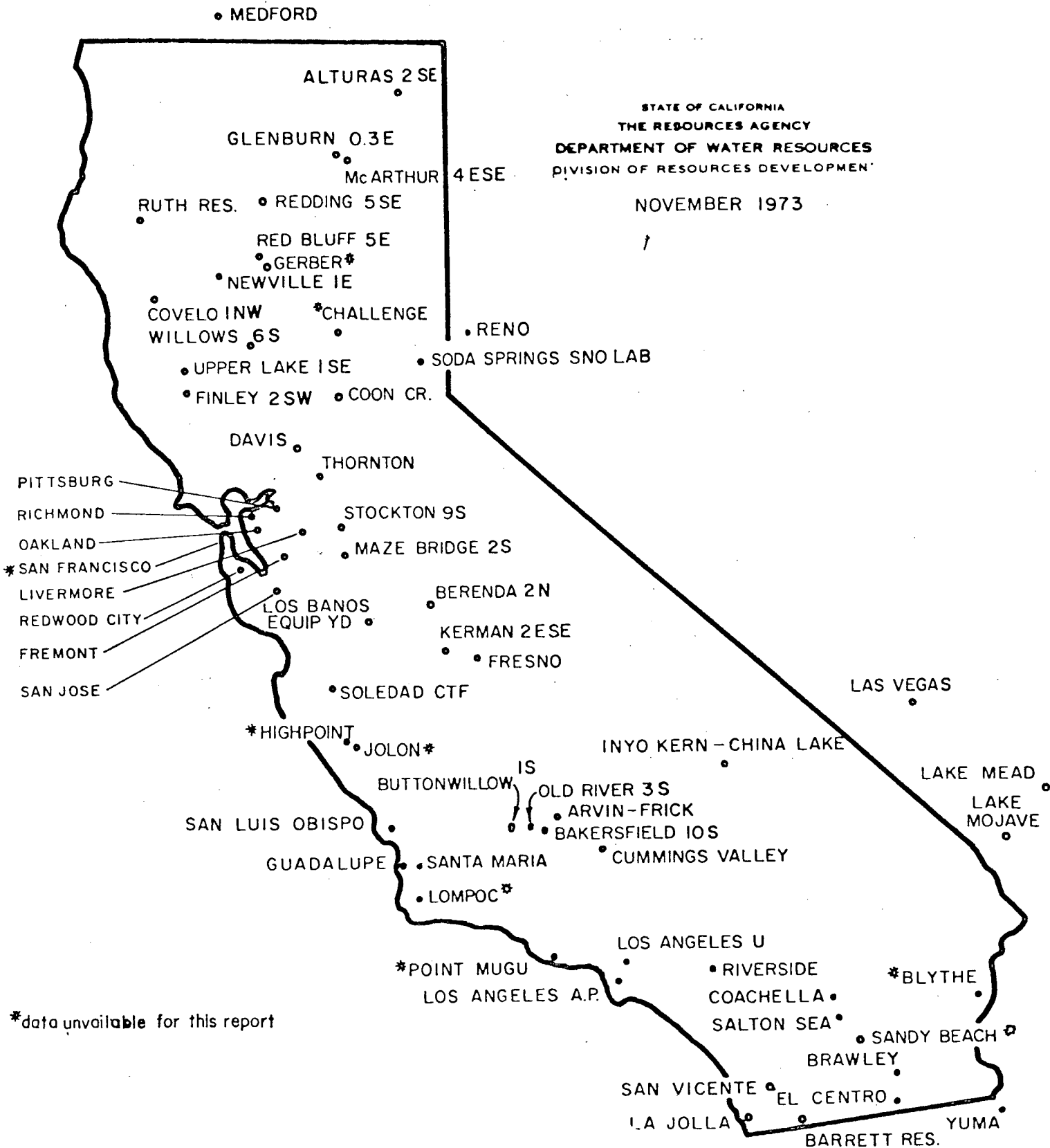
Organization of the Solar Data Base

Data on the solar systems in this study were collected directly from the owners and/or builders of the system, with some contributions from secondary sources. The sources are listed at the bottom of each data sheet. No independent check was made on the accuracy of the information: in particular, system performance has not been checked by Lawrence Berkeley Laboratory, and represents the estimate of the individual quoted.

Data Sheets: From the data collected during the survey, we have compiled a single data sheet on each of the 60 systems in the survey. Each data sheet contains a brief summary of key information on the system, followed by more detailed information on the building, solar system, collector, storage, auxiliary (backup) costs, and performance to date. Data sheets are arranged in alphabetical order by an identifying code used to protect the privacy of the owners. Format of the data sheets is summarized on page 29.

Index: For reference purposes, key information on each system in the two major categories (solar hot-water heating and solar space heating and cooling) has been summarized in an Index section, and cross-referenced by page. Entries are alphabetical by identifying code.

FIGURE 1
LOCATION OF SOLAR RADIATION STATIONS IN CALIFORNIA



Summary Tables: Cost data with a breakdown into materials and labor components were abstracted for the Summary Tables, in order to facilitate direct comparison of system costs. Summary Tables also include cost figures on a per-square-foot-basis, and system size.

Because of time constraints, all systems located could not be included in the data base. A blank data sheet is included at the end of the Data Sheets section for adding information.

This data collection is an on-going project of Lawrence Berkeley Laboratory. If you have built (or know of) a Northern California solar system not included here, please contact Solar Data Project, Energy Conservation Assessment Group, Lawrence Berkeley Laboratory, Berkeley, CA 94720.

Costs

Costs of systems located vary widely. Where possible, a cost breakdown (materials, labor, collector, storage, other) was obtained. Sometimes (as with passive systems) the cost of the solar system is difficult to isolate from the cost of the building; in these cases, the cost of the solar system is considered to be the cost of all components not essential to the basic building envelope (an added-on cost).

The primary variable in system costs is the labor component: owner-built systems are invariably less expensive than contractor-built or partially contracted systems, and form a special group. Materials costs were isolated from total systems costs for contractor-built systems wherever possible to enable a straight-across comparison of the non-labor component of system costs. In these cases, a clearer evaluation of the relative merits of different technologies represented in the sample can be carried out.

The convention of evaluating systems cost on a cost-per-ft² basis ($\frac{\text{cost of system installed}}{\text{square foot of collector}}$) is widely accepted. This convention enables a comparison of different size systems but ignores efficiency factors, thus discriminating against the smaller but more efficient (and usually more expensive per ft²) systems. The convention becomes especially tricky in the consideration of passive-type systems, where square footage of collector is taken to be square footage of south-wall glass or south-roof skylight area, and the cost-per-ft² figure then becomes highly

sensitive to glass area. A more realistic comparison figure would be cost per kBtu collected, or cost per kBtu collectible under various typical insolation conditions. In many cases this figure could be computed without great difficulty, to fairly good accuracy, and would provide a more sophisticated figure-of-merit for comparison of different systems.

Where possible, systems cost is expressed as cost per ft² (entire installed system cost), cost per ft² (materials cost only) and cost per ft² (labor cost only).

Most cost-effective of the systems located were the so-called passive-type systems, whether owner or contractor built. In some cases, the solar heating/cooling system was so integral to the house structure that add-on cost was zero or nominal. The simplest kinds of passive system were difficult to distinguish from a well-designed (solar-tempered or climate-oriented) structure, and it became evident that buildings could be ranged on a continuum (energy-conserving buildings, solar-tempered buildings, passive-type solar heated/cooled buildings, and active-type solar heated/cooled buildings), with the line distinguishing solar-tempered or climate-oriented buildings from solar heated/cooled buildings difficult to draw.

Life-Cycle Costing

Considerable diversity exists in analyses of the "value" of an installed solar system, both in assumptions and in methodology. Clearly, first cost, system lifetime, lifetime maintenance cost, displaced fuel cost (variously estimated over the system lifetime), and capital cost are all of importance in evaluating "true value" of the installed system. Beyond this point, however, analyses diverge.

Two factors emerged from this brief study which cast some light on the controversy:

- (1) System owners surveyed in the sample who considered economics of the purchase or construction of a system

to be of relatively high importance expected a payback of the system within a time period relevant to them.

This time period varied greatly.

- (2) Any life-cycle costing for solar systems must be quite dependent on the technology considered as the various technologies differ, clearly and significantly, in first cost as well as in efficiency (fuel displaced), probable system lifetime, probable lifetime-maintenance cost, and probable resale value.

Technology

It is evident that solar technology has been applied with increasing sophistication and success in building climate control. Almost all of the systems within this sample were built within the last two years, and within this period, systems technology seems to have improved (as better information became available) and systems costs seem to have decreased.

Evaluation of effectiveness of competing technologies for solar space heating, cooling, and hot-water heating was beyond the scope of this study. But the considerable data necessary to such an evaluation are becoming available; quite a few of the systems located are now (or will be) instrumented for study.

SUMMARY TABLES

TABLE I: Solar Hot-Water Heating Systems

System Location Date Built	Owner Built/ Contractor Built	New/ Retrofit	Auxiliary System	Ft ² Collector/ Gallons Storage	Cost: System	Cost: Materials	Cost: Labor	Cost/ Ft ²	Cost/ Ft ² Materials	Cost/ Ft ² Labor
IRVG Cotati 10/74	OB	R	Electric	15 20	\$ 45	\$ 45	0	\$ 3.00	\$ 3.00	0
SMT Aptos 7/75	CB	R	Electric	56 100	\$2,060	\$1,260	\$ 800	\$36.79	\$22.50	\$14.29
SPHS Berkeley 6/76	CB	N	Electric	60 120	\$1,200	\$ 700	\$ 500	\$20	\$11.67	\$ 8.33
LNDQT Davis 3/76	CB	N	Gas	60 82	\$ 950	\$ 627	\$ 323	\$15.83	\$10.45	\$ 5.38
JFFR Kentfield 3/76	CB	N	Electric	54 100	\$1,200	\$ 700	\$ 500	\$22.22	\$12.96	\$ 9.26
CRBT Davis 3/76	CB	N	Gas	100 82	\$1,519	\$1,050	\$ 469	\$15.19	\$10.50	\$ 4.69
HFCR Davis 9/76	CB	N	Gas	80 82						
RTN Davis 12/75	CB	N	Electric	100 82	\$1,500	\$1,066	\$ 434	\$15	\$10.66	\$ 4.34
FT Napa 12/75	CB	R	Electric	50 100	\$1,400	\$ 550	\$ 850	\$28	\$11	\$17
ADMN Berkeley 10/74	OB	R	Gas	32 40	\$ 500	\$ 500	0	\$15.63	\$15.63	0
BYL Sebastopol 5/75	OB	R	Electric	32 40	\$ 40	\$ 40	0	\$ 1.25	\$ 1.25	0
CSEF Fetters Hot Springs 5/75	OB	R	Electric	32 40	\$ 35	\$ 35	0	\$ 1.09	\$ 1.09	0
HSR-MFR Davis 4/76	CB	N	Gas	60 82	\$ 950	\$ 627	\$ 323	\$15.83	\$10.45	\$ 5.38
GDE Sonoma 6/76	CB	N	Electric	40 120	\$1,240	\$ 560	\$ 680	\$31	\$14	\$17

TABLE I: Solar Hot-Water Heating Systems (Cont.)

System Location Date Built	Owner Built/ Contractor Built	New/ Retrofit	Auxiliary System	Ft ² Collector/ Gallons Storage	Cost: System	Cost: Materials	Cost: Labor	Cost Ft ²	Cost/ Ft ² Materials	Cost/ Ft ² Labor
RDBS Sausalito 4/76	OB/CB	N	Gas	80 120	\$ 720	\$ 720	0	\$ 9	\$ 9	\$ 0
TRK Santa Rosa	CB	R	Electric	50 120	\$ 1,200			\$24		
NHSR Occidental 5/76	OB	N	Electric	40 120	\$ 600	\$ 600	0	\$15	\$15	0
IRIS Mill Valley 4/76	CB	R	Gas	640 360	\$11,240			\$17.56		
FRTR Bodega Bay 5/76	CB	N	Electric	330						
HCHC Winters Late 1976	CB	N	Electric	70 80	\$ 1,000			\$14.29		
Farallones Berkeley 8/75	OB	R	Electric	86.4 120	\$ 1,058	\$1,058		\$12.25	\$12.25	
Scotty's Castle Death Valley 1929	CB	N								
GRBR Walnut Creek 11/75	CB	R	Gas & Electric	50 60	\$1,000	\$ 550	\$ 450	\$20	\$11	\$ 9
Mills Valley* Center 5/75	CB	N	Electric	500						
FRLNS Occidental 10/75	OB	N	Wood	32 120	\$100-200	\$100-200	0	\$ 3.13 6.26		
EAO Modesto 1/76	OB	R	None	24 80	\$ 160	\$ 160		\$ 6.67	\$ 6.67	
DFP Tomales 6/75	OB	R	Electric	12 15	\$	\$		\$ 2.08	\$ 2.08	

TABLE II: Solar Space Heating and Cooling Systems

System Location Date Built	Owner Built/ Contractor Built	Active/ Passive	New/ Retrofit	Auxiliary System	Ft ² Collector	Cost: System	Cost: Materials	Cost: Labor	Cost/ Ft ²	Cost/ Ft ² Materials	Cost/ Ft ² Labor
FRTR Bodega Bay 5/76	CB	A	N	Electric	330						
HAY Atascadero 1973	CB	P	N	Electric	1200						
BLKNS Berkeley 4/76	OB/CB	P	N	Electric	600						
ISC Various Various		A		Various	96 128 160	\$3,100 \$3,690 \$4,380	\$2,600 \$3,140 \$3,780	\$ 500 \$ 550 \$ 600	\$32.29 \$28.83 \$27.38	\$27.08 \$24.53 \$23.63	
WTMN* Sacramento 1/76	CB		R	Gas	381	\$6,000					\$15.75
WRD* Davis 7/74	CB	A/P	N	Gas	200	\$3,510					\$17.55
RYN Jenner 8/76	CB	A/P	N	Electric	400						
SCRec Santa Clara Spring 1976	CB	A	N	Gas	6500	\$436,000				\$67.08	
GDE Sonoma 6/76	CB	A	N	Electric	360	\$ 6,080	\$3,040	\$3,040	\$16.88	\$ 8.44	\$ 8.44
RDBS Sausalito 4/76	OB/CB	A	N	Electric	640	\$ 4,160	\$4,160	0	\$ 6.50	\$ 6.50	0
TRKL Santa Rosa	CB	A	R	Electric		\$ 1,200					
NHSR Occidental 5/76	OB	P	N	Electric	192	\$ 400	\$ 400	0	\$ 2.08	\$ 2.08	0
HTN Berkeley	OB	A	R	Gas	288	\$ 900	\$ 900	0	\$ 3.12	\$ 3.12	0

TABLE I: Solar Space Heating and Cooling Systems (cont)

System Location Date Built	Owner Built/ Contractor Built	Active/ Passive	New/ Retrofit	Auxiliary System	Ft ² Collector	Cost: System	Cost: Materials	Cost: Labor	Cost/ Ft ²	Cost Ft ² Materials	Cost/ Ft ² Labor
Self-Help Enterprises Visalia Late 1976	OB/CB	P	N		1200	\$ 4,000				\$ 3.33	
SHWD Winters 4/75	CB	P	N	Gas	400	\$ 4,000			\$10		
HCHC Chico Late 1976	CB	P	N	Wood	300	\$ 4,000			\$13.33		
DSCI Davis Late 1976	CB	P	N		250						
Hewlett P Sunnyvale Fall 1973	CB	A	R	Gas	7000	\$18,000	\$18,000	0	\$ 2.57	\$ 2.57	0
HMND Winters Summer 1974	OB	P	R	Gas & Wood	200	\$ 500	\$ 500	0	\$ 2.50	\$ 2.50	0
LNDQT Davis Summer 1976	OB/CB	P	N	Gas	155	\$ 600	\$ 400	\$ 200	\$ 3.87	\$ 2.58	\$ 1.29
JFFR Kentfield 11/75	CB	A	N	Gas	900						
CSCS Rohnert Park 5/75	OB	P	N	Wood	220	\$ 200	\$ 200	0	\$.91	\$.91	0
GBL Petaluma 12/74	OB	A	R		300	\$1,600	\$1,600	0	\$ 5.33	\$ 5.33	0
GSPRS Tomales	OB/CB	P	R		120	\$ 500	\$ 150	\$ 350	\$ 4.17	\$ 1.25	\$ 2.92
Scotty's Castle Death Valley 1929	CB	A	N								
HFCR Davis 9/76	OB/CB	P	N	Gas	162	\$1,000	\$1,000		\$ 6.17	\$ 6.17	

TABLE III: Integrated Systems for Solar Space Heating/Cooling and Solar Hot-Water Heating

System Location Date Built	Owner Built/ Contractor Built	New/ Retrofit	Auxiliary System	Ft ² Collector/ Gallons Storage	Cost: System	Cost: Materials	Cost: Labor	Cost Ft ²	Cost/ Ft ² Materials	Cost/ Ft ² Labor
WTMN* Sacramento 1/76	CB	R	Gas	381	\$6,000			\$15.75		
WRD* Davis 7/74	CB	N	Gas	200	\$3,510			\$17.55		
MCF* San Jose 5/75	OB	R	Gas	533	\$2,100	\$ 3.94	0	\$ 3.94	\$ 3.94	0
HNMN* Sunnyvale 10/75	CB	R	Gas	350						
BSH* Livermore 1/75	OB	R	Gas	400	\$1,500	\$1,500	0	\$ 3.75	\$ 3.75	0
BNE* Palo Alto 11/75	CB	R	Gas	640						
LKS* Sacramento 6/76	OB	N		400						

*Integrated Systems for Solar Space Heating/Cooling and Hot Water Heating

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Solar Hot-Water Heating Systems

- Page
30 ADMN/Berkeley/Solar hot-water heating (\$500) October 1974
Retrofit/single-family residence/owner built/gas backup.
Tube-on-plate flat-plate collector/thermosiphon/with water
storage. Preheater/pressurized system.
- 32 BNE/Palo Alto/Solar space and hot-water heating/(\$)November 1975
Retrofit/single-family residence/contractor built/gas backup. Tube-
in-plate flat-plate collector/pumped/water circulating/with water
storage. Integrated space heating and hot-water heating system.
- 33 BRKYL Builders/Berkeley/Solar hot-water heating (\$1145) March 1976
New construction/single-family residence/contractor built/electric
backup. Tube-on-plate collector/pump/water circulating/with water
storage.
- 34 BUSH/Livermore/Solar space heating and hot-water heating (\$1500)
January 1975
Retrofit/single-family residence/owner built/gas backup. Trickle-
type system/flat-plate collector/water circulating/pumped/with
water storage. Integrated space heating and hot-water heating.
- 35 BYL Residence/Sebastopol/Solar hot-water heating (\$40) May 1975
Retrofit/single-family residence/owner built/electric backup.
Free-standing tank-type collector/thermosiphon/water circulating/
with water storage.

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36 CRBT duplexes/Davis/Solar hot-water heating (\$1519 for two) March 1975

New construction/duplex/contractor built/gas backup/roof-mounted tube-on-plate flat-plate collector/water circulating/with water storage.

38 CSEF Residence/Fetters hot springs/Solar hot-water heating (\$35) May 1975

Retrofit/single-family residence/owner built/electric backup. Free-standing tank-type collector/thermosiphon/water circulating/with water storage.

39 DFF Residence/Tomales/Solar hot-water heating (\$25) Summer 1975

Retrofit (portable) single-family residence/owner built/no backup. Free-standing/flat-plate collector/thermosiphon/water circulating/with water storage.

41 Ecology Action Office/Modesto/Solar hot-water heating (\$160) January 1976

Retrofit/office building/owner built/free-standing Roll-Bond flat-plate collector/thermostat-activated pump/water circulating/with water storage.

42 Farallones Urban House/Berkeley/Solar hot-water heating (\$1058) August 1975

Retrofit/residence and classroom/built by staff/electric backup/roof-mounted tube-on-plate flat-plate collector/thermosiphon/water circulating/with water storage.

43 FRLNS (Farallones Rural Center)/Occidental/Solar hot-water heating (\$100-\$200) Fall 1975

New construction/bath house for school/owner built/wood-burning backup/roof-mounted tank collector (breadbox)/water circulating/with water storage.

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FRTR/Bodega Bay/Solar hot-water heating (\$) May 1976

New construction/single-family residence/owner-contractor built/
electric backup/sandwich-type flat-plate collector/pumped water
circulating/with water storage. Integrated solar space heating
and hot-water heating system.

46 FT/Napa/Solar hot-water heating (\$1400) December 1975

Retrofit/single-family residence/contractor built/electric backup.
Copper tube-on-plate/flat plate collector/thermosiphon/water
circulating/with water storage.

47 GDE/Sonoma/Solar hot-water heating (\$1240) Summer 1976

New construction/single-family residence/contractor-built/electric
backup/tube-on-plate flat-plate collector/pumped water circulating/
with water storage.

50 GRBR/Walnut Creek, Solar hot-water heating (\$1000) November 1975

Retrofit/single-family residence/contractor built/gas and electric
backup/tube-on-plate flat-plate collector/thermosiphon/water
circulating/with water storage.

53 HCHC/Chico/Solar hot-water heating (\$1000 estimated) Late 1976

New construction/single-family residence/contractor built/electric
backup/flat-plate collector/water circulating/thermosiphon/with
water storage.

57 HFCR/Davis/Solar hot-water heating (\$) September 1976

New construction/single-family residence/contractor built/gas backup/
roof-mounted flat-plate collector/thermosiphon/water circulating/
with water storage.

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59 HNMN/Sunnyvale/Solar space and hot-water heating (\$) October 1975

Retrofit/single-family residence/contractor built/gas backup. Tube-in-plate flat-plate collector/pumped/water circulating/with water storage. Integrated space heating and hot-water heating system.

60 HSRMFR Houser-Mecfesser/Davis/Solar hot-water heating (\$950) April 1976

New construction/single-family residence/contractor built/gas backup/roof-mounted tube-on-plate/flat-plate collector/thermosiphon/water circulating/with water storage.

62 IRIS Images/Mill Valley/Solar hot-water heating (\$11,240) April 1976

Retrofit/commercial: film processing/contractor built/gas backup/roof-mounted tube-on-plate flat-plate collector/pumped water circulating/with water storage. Designed to provide large quantity of 100-deg hot water for immediate daytime use in film processing.

63 IRVG Residence/Cotati (Sonoma County)/Solar hot-water heating (\$40) October 1974

Retrofit/mobile home/owner built/flat-plate collector/electric backup/thermosiphon/water circulating/with water storage.

66 JFFR/Kentfield/Solar hot-water heating (\$1200) March 1976

New construction/single-family residence/contractor built/electric backup/roof-mounted flat-plate collector/water circulating/with water storage.

67 LKS/Sacramento/Solar space heating and cooling and hot-water heating (\$) July 1976

New construction/single-family residence/owner built/combo passive-type system (south-facing Thermopane windows with concrete slab floor storage) and active-type system (air-type collector with rock storage). Separate water-circulating flat-plate collector with water storage for domestic hot water.

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69 INDQT Residence/Davis/Solar hot-water heating (\$950) March 1976

New construction/duplex/contractor built/gas backup/roof-mounted copper tube-on-plate flat-plate collector/thermosiphon/water circulating/with water storage.

71 MCF/San Jose/Solar hot-water heating (\$) May 1975

Retrofit/single-family residence/owner built/gas backup. Integrated system for space heating, hot-water heating, and heating of swimming pool.

72 MLS/Valley Center/Space heating and cooling and hot-water heating (\$) May 1975

New/single-family residence/contractor built/electric backup/roof-mounted flat-plate collector/pumped-water circulating/with water storage. Integrated solar system for space heating, space cooling, and hot-water heating (heat exchanger in storage tank).

74 NHSR/Occidental (Sonoma County)/Solar hot-water heating (\$600) May 1976

New construction/single-family residence/owner built/electric backup/tube-on-plate flat-plate collector/water circulating/with water storage.

75 RDBS Residence/Sausalito/Solar hot-water heating (\$930) April 1976

New construction/single-family residence/owner and contractor built/gas backup. Combined space and hot-water heating. Tube-on-plate flat-plate collector/pumped water circulating/with water storage.

77 RTN Residence/Davis/Solar hot-water heating (\$1500) December 1, 1975

New construction/single-family residence/contractor built/electric backup/tube-on-plate flat-plate collector/thermosiphon/water circulating/with water storage.

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Scotty's Castle/Death Valley/Solar heating and solar hot-water heating (\$) 1929

New construction (1929)/residence/backup not specified/tube-on-plate flat-plate collector/water circulating/with water storage.

83 SMT Residence/Aptos/Solar hot-water heating (\$2060) July 1975

Retrofit/single-family residence/contractor built/electric backup/flat-plate collector/pumped water circulating/with water storage.

84 SPHS/Berkeley/Solar hot-water heating (\$1200) June 1976

New construction/single-family residence/contractor built/electric backup/tube-on-plate flat-plate collector.

85 TRK/Santa Rosa/Solar hot-water heating (\$1200) Summer 1976

Retrofit/single-family residence/contractor built/electric backup. Integrated system installed with new swimming pool to provide pool heating, space heating, hot-water heating, and spa heating. Uses water-to-air heat pump from swimming pool.

87 WRD Residence/Davis/Solar hot-water heating and space heating (\$3510 SH & HWH) July 1974

New construction/single-family residence/contractor built/gas backup/roof-mounted sandwich-type flat-plate collector/thermosiphon/water circulating/with water storage. Also passive-type system (windows with movable insulation). Integrated space heating and hot-water heating.

88 WTMN/Sacramento/Solar space heating, cooling, and hot-water heating (\$6000) January 1976

Retrofit/single-family residence/contractor built/gas backup/roof-mounted flat-plate collector/pumped water circulating/with water storage. Integrated space heating, cooling, and hot-water heating system.

Solar Space Heating and Cooling Systems

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- 31 BLKNS/Berkeley/Solar space heating (\$)April 1976
New construction/single-family residence/owner-contractor built/
electric backup/passive system utilizing south-facing windows.
- 32 BNE/Palo Alto/Solar space and hot-water heating(\$)November 1975
Retrofit/single-family residence/contractor built/gas backup/tube-
in-plate flat-plate collector/pumped water circulating/with water
storage. Integrated space heating and hot-water heating system.
- 34 BUSH/Livermore/Solar space heating and hot-water heating (\$1500-
2000)
Retrofit/single-family residence/owner built/gas backup. Trickle-
type system/flat-plate collector/water circulating/pumped/with
water storage. Integrated space heating and hot-water heating.
- 37 CSCS Energy Center/Rohnert Park/Solar heating and cooling (\$200)
May 1975
New construction/classroom/student built/wood-stove backup.
Passive-type system utilizing 60-deg south-facing wall with
water-filled gallon jugs and moveable insulation.
- 40 DSCL/Davis/Solar space heating and cooling (\$35,000 for 1500 ft²
building)
New construction/school/contractor built/passive-type heating and
cooling using south-facing glass wall with 21-in diameter water-
filled steel tubes as collector and storage.
- 44 FRTR/Bodega Bay/Solar space heating (\$)May 1976
New construction/single-family residence/owner-contractor built/
electric backup/sandwich-type flat-plate collector/pumped water
circulating/with water storage. Integrated solar space heating
and hot-water heating system.

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48 GDE/Sonoma/Solar space heating (\$6080) Summer 1976

New construction/single-family residence/contractor built/electric backup/tube-on-plate flat-plate collector/pumped water circulating/with water storage.

49 GEBL/Petaluma/Solar space heating (\$1600) Winter 1974-75

Retrofit/greenhouse added to residence/owner built/backup not specified/flat-plate collectors (Fafco brand)/water circulated by pumps/water storage/heat distributed by radiant baseboard heater.

51 GSPRS Residence/Tomaes/Solar space heating (\$150/\$500)

Retrofit/single-family residence/owner built/added south-facing greenhouse with passive-type system (bottle wall) using water-filled jugs as collector and storage. Heat enters house through ducts located at top of greenhouse.

52 Hay (Skytherm)/Solar space heating and cooling (\$) 1973

New construction/single-family residence/contractor built/passive system using water-filled plastic bags on roof with moveable, insulated panels/integrated collector, storage, distribution system.

54 HCHC/Chico/Solar space heating and cooling (\$4000 estimated) Late 1976

New construction/single-family residence/contractor built/wood backup. Passive-type system using south-facing windows with moveable insulation and 21-in-diameter steel tubes (water-filled) for storage.

55 Hewlett-Packard Plant/Sunnyvale/Solar space heating (\$18,000) Fall 1973

Retrofit/165,000 ft² industrial plant/built by plant maintenance₂ personnel/gas backup/roof-mounted flat-plate collectors (7000 ft²) retrofitted to existing terminal-reheat system/pumped water circulating/with water storage.

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- 56 HFCR/Davis/Solar space heating and cooling (estimate less than \$1000) September 1976

New construction/single-family residence/owner-contractor built/gas backup/passive system utilizing south-facing windows with 50-gal water-filled drums, slab floor for storage, and moveable, insulating shutters.

- 58 HMND/Winters/Solar space heating and cooling (\$500) Summer 1974

Retrofit/single-family residence/owner built/gas and wood backup/passive-type system/south wall/water-filled 55-gal drums inside vertical window wall/with moveable insulation.

- 59 HNMN/Sunnyvale/Solar space and hot-water heating (\$)October 1975

Retrofit/single-family residence/contractor built/gas backup/tube-in-plate flat-plate collector/pumped water circulating/ with water storage. Integrated space heating and hot-water heating system.

- 61 HTN/Berkeley/Solar space heating (\$900)

Retrofit/duplex residence and office/owner built/gas backup/roof-mounted trickle-type (Thomason) collector/pumped water circulating/with water storage.

- 64 ISC (Champion Homebuilders)/Various Locations/Solar heating and cooling (\$2600:96 ft², \$3140:128 ft²) 200+ units

Modular mass-produced solar heating and cooling unit. Freestanding/air collector/with rock storage/attaches to forced air heating and cooling systems of existing or new structures.

- 65 JFFR/Kentfield/Solar space heating (\$) November 1975

New construction/single-family residence/contractor built/gas backup/roof-mounted trickle-type collector/water-circulating/pumped with water storage.

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67 LKS/Sacramento/Solar space heating and cooling and hot-water heating (\$) July 1976

New construction/single-family residence/owner built/combination passive-type system (south-facing Thermopane windows with concrete slab floor storage) and active-type system (air-type collector with rock storage). Separate water-circulating flat-plate collector with water storage for domestic hot water.

68 LNDQT Residence/Davis/Solar heating and cooling (\$400-600 estimated) Summer 1976

New construction/duplex/contractor built/gas backup/passive-type system utilizing south-facing windows and skylight with slab floor for storage and moveable insulation (shutters).

70 MCF/Solar space heating (\$) May 1975

Retrofit/single-family residence/owner built/gas backup. Integrated system for space heating, hot-water heating, and heating of swimming pool.

72 MLS/Valley Center/Space heating and cooling and hot-water heating (\$) May 1975

New/single-family residence/contractor built/electric backup/roof-mounted flat-plate collector/pumped-water circulating/with water storage. Integrated solar system for space heating, space cooling, and hot-water heating (heat exchanger in storage tank).

73 NHSR/Occidental/Solar space heating and cooling (\$400) May 1976

New construction/single-family residence/owner built/electric backup. Passive-type system with double-glazed south-facing windows and slab floor, moveable insulating shutters. Greenhouses on east and west of house, north exposure bermed (wine cellar).

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76 RDBS/Sausalito/Solar space heating (\$4160) April 1976

New construction/single-family residence/owner and contractor built/gas backup. Space and hot-water heating. Tube-on-plate flat-plate collector/pumped water circulating/with water storage.

78 RYN Residence/Jenner (Sonoma County)/Solar space heating (\$) August 1976

New construction/single-family residence/contractor built/electric backup/free-standing Roll Bond flat-plate collector/pumped/with water storage. Integrated space heating and hot-water heating.

79 Santa Clara Community Recreation Center/Santa/Clara Solar space heating and cooling (\$436,000) Early 1976

New construction/recreation center/contractor built/gas backup/roof-mounted flat-plate collectors/pumped water circulating/ with water storage.

80 Scotty's Castle/Death Valley/Solar heating and solar hot-water heating (\$) 1929

New construction (1929)/residence/backup not specified/tube-on-plate flat-plate collector/water circulating/with water storage.

81 Self-Help Enterprises/Visalia/Solar space heating and cooling (\$4000) Late 1976

New construction/single-family residences (5)/owner and contractor built. Passive-type system/Skytherm design/ integrated collection and storage/roof-top water bags/with moveable insulation.

82 SHWD/Winters/Solar space heating and cooling (\$4000) April 1975

New construction/single-family residence/contractor built/gas and wood backup. Passive-type system/roof-mounted, water-filled tanks with moveable, insulated, reflective lids/south-facing with insulated shutters/slab floor and water-filled drums.

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86 TRK/Santa Rosa/Solar space heating (\$) Summer 1976

Retrofit/single-family residence/contractor built/electric backup. Integrated system installed with new swimming pool to provide pool heating, space heating, hot-water heating, and spa heating. Uses water-to-air heat pump from swimming pool.

87 WRD Residence/Davis/Solar hot-water heating and space heating (\$3510) July 1974

New construction/single-family residence/contractor built/gas backup/roof-mounted sandwich-type flat-plate collector/thermo-siphon/water circulating/with water storage. Also passive-type system (windows with moveable insulation). Integrated space heating and hot-water heating.

88 WTMN/Sacramento/Solar space heating, cooling, and hot-water heating (\$6000) January 1976

Retrofit/single-family residence/contractor built/gas backup/roof-mounted flat-plate collector/pumped water circulating/with water storage. Integrated space heating, cooling, and hot-water heating system.

90 XFLNS-A/Occidental/Solar space heating and cooling (\$200) September 1976

New/cabin/student-built/electric backup. Passive type system/forced air-circulating (fan) with thermal storage of river rock plus slab floor.

91 XFLNS-B1/Occidental/Solar space heating and cooling (\$350) September 1976

New/cabin/student-built/electric backup. Passive type system/forced air-circulating (fan) with thermal storage of river rock slab floor over rock. Also roof pond with moveable insulating lid and reflector.

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92 XFLNS-C/Occidental/Solar space heating and cooling (\$350)
September 1976

New/cabin/student-built/electric backup. Passive type system with south glass, and slab floor plus rock bed storage, air-circulating with small fan. Also flat plate (air) collector.

93 XFLNS-D/Occidental/Solar space heating and cooling (\$200)
September 1976

New/cabin/student-built/electric backup. Passive type system with greenhouse collector. Heated air circulated into house and rock bed storage under slab by a small fan.

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DATA SHEETS

DATA SHEETS

Format for Data Sheets

Systems are identified by code to protect the privacy of owners. Additional information may be available from architect (see Source at bottom of data sheet.)

There is one data sheet for each system: a brief summary of key information can be found at the top of the page, followed by more detailed information on the system.

Building: Includes building type and size, with additional information where available. New/retrofit refers to when system was installed, whether at the time of construction of the residence or as an addition to existing residence.

System: Briefly describes system in terms of basic components, particularly with reference to active/passive systems, air/water systems, transfer and control mechanisms.

Collector: Describes collector portion of the system in greater detail, including materials used, size, number of glazing surfaces, coatings used.

Storage: Describes size and type of storage, location in building.

Auxiliary: Describes type of backup system (electric, gas, wood, other) and size. In some cases, storage tank and auxiliary are identical.

Costs: Where possible, a very detailed description of costs was obtained, in particular as regards labor costs vs materials costs. Costs identified under Solar column represent costs of entire system (added-on cost where costs are ambiguous). Costs identified under Collector and Storage columns represent portion of total cost of system entailed in collector and storage portions of the system. Costs identified under Aux/Other column represent cost of pumps, controls, transfer system, and design or other fees, where so identified. Where costs are in parentheses, quantities represent estimated labor cost for contractor-built system (when originally owner built) and estimated materials cost for new materials (when recycled materials used).

Performance: Indicates estimated performance, where indicated by owner or builder (% of needs or fuel saved), and measured performance where such information is available. Notes systems which have been or are being instrumented for quantitative study.

Additional Info: References or other interesting information on system.

Sources: Identifies sources of data.

ADMN/Berkeley/Solar hot-water heating (\$500) October 1974

Retrofit/single-family residence/owner built/gas backup.
Tube-on-plate flat-plate collector/thermosiphon/with water storage. Preheater/pressurized system.

Building: Existing single-family residence.

System: Retrofit/HWH/tube-on-plate flat-plate collector/water circulating/thermosiphon/with water storage. System designed and built by owner. System at city water pressure.

Collector: 32 ft²/water-circulating flat plate/double glazing: outer-sheet plexiglas, inner-sheet glass, with one-inch separation. Collector plate consists of 3/4-in copper tubes wired and soldered to galvanized steel plate (4ft x 8ft) painted with flat black paint.

Storage: 40-gal glass-lined steel tank in attic.

Auxiliary: 20-gal gas-fired water heater in series (after storage tank).

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$500			
Labor	\$ 0			
Total	\$500			

Performance: 75% estimated. 40-gal storage tank seldom drops below 90°F. Plumbed so always acts as preheater for gas hot-water heater; on sunny days gas heater does not go on at all.

Additional Info: Built primarily of recycled materials by owner over a seven-month period 3/74 - 10/74. Total storage: 40-gal tank in attic plus hot-water heater tank (20 gal).

Source(s): Owner.

BLKNS/Berkeley/Solar space heating (\$) April 1976

New construction/single-family residence/owner-contractor built/
electric backup/passive system utilizing south-facing windows, but
no storage.

Building: New/single-family residence/924 ft² and loft/wood-frame
construction.

System: New/space heating/passive-type system with tilted south-
facing window wall. No storage. System designed by
Harry Glasscock.

Collector: About 600 ft²/passive-type system with south-facing wall
tilted at 62.5 deg. Bottom 1/3 single-glazed with window
glass, top 2/3 single-glazed with acrylic. Owner-contractor
built.

Storage: None. Thermal mass of house is the only storage at present.

Auxiliary: Electric radiant wall heaters.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: House tends to overheat on sunny days unless vented. Little
heat storage due to low thermal mass.

Additional Info: System basically completed, but being modified. More
thermal mass will be added.

Source(s): Owner

BNE/Palo Alto/Solar space and hot-water heating (\$) November 1975

Retrofit/single-family residence/contractor built/gas backup. Tube-in-plate flat-plate collector/pumped water circulating/with water storage. Integrated space heating and hot-water heating system.

Building: Retrofit/existing single-family residence/2000 ft.² Oriented due south, with flat roof.

System: Retrofit/SH and HWH/flat-plate collector/pumped/water (with additives) circulating/with water storage. System is integrated with existing radiant floor-heating system/fully automatic controls. System designed and built by Alten Associates, Santa Clara, CA.

Collector: 640* ft² /water-circulating flat plate/double glazing of Tedlar/wood frame. Absorber is Olin Brass Roll-Bond aluminum plate.

Storage: 2000-gal steel tank/insulated with 3-in polyurethane foam/located underground.

Auxiliary: Gas furnace and gas hot-water heater.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

\$1250*

Performance: 70% (estimated).

Additional Info: *Twenty-seven 3ft x 8ft collectors arrayed in three ranks of 12, 11, and 4 each. Contractors discount price - includes delivery and installation. System is interfaced to existing radiant floor heating system and hot-water heater.

Source(s): Owner; Klaus Heinemann (Alten Associates, Santa Clara, CA.)

BRKYL Builders/Berkeley/Solar hot-water heating (\$1145) March 1976

New construction/single-family residence/contractor built/electric backup.
 Tube-on-plate collector/pump/water circulating/with water storage.

Building: New/speculative house by Berkeley Builders.

System: New/HWH/flat-plate collector/water circulating/pump/with water storage. System designed and built by Berkeley Solar Group.

Collector: 36 ft²/ water-circulating flat plate/copper tubes mechanically bonded to aluminum plate (Raypack)/single glazing of Tedlar-coated fiberglass/fiberglass insulation.

Storage: 120-gal glass-lined steel tank.

Auxiliary: Electric element in storage tank.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials		\$4.50/ft ² plate	\$240	\$635*
Labor		0.70/ft ² glaze		
Total				

Performance: 50% estimated.

Additional Info: House is for sale. Contact Berkeley Builders.

*Controller - \$40, Pump - \$45, Plumbing - \$100,
 Fees - \$450.

Source(s): Berkeley Solar Group, Berkeley, CA

BUSH/Livermore/Solar space heating and hot-water heating (\$1500) 1969

Retrofit/single-family residence/owner built/gas backup. Trickle-type system flat-plate collector/water circulating/pumped/with water storage. Integrated space heating and hot-water heating.

Building: Existing/single-family residence/1400 ft²/single story/ three bedrooms/built in 1969. Wood-frame construction. Oriented south.

System: Retrofit/space heating/trickle-type system/water circulating/pumped/with water storage. System integrated with existing forced-air space heating and domestic hot-water heating systems. Solar system controlled by home-built differential controller.

Collector: 400 ft² /trickle-type flat-plate collector/water circulating/ single glazing of greenhouse glass (20 in x 24 in lights)/ absorber plate consists of black painted corrugated aluminum sheets/wood frame/4in. fiberglass insulation.

Storage: 1000 gal/water/in two 500-gal capacity galvanized steel culvert sections (estimated 20 year life in the ground). Steel tank for preheating domestic hot water located in one of the culvert sections.

Auxiliary: Central gas furnace and forced-air heating system. Gas hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$1500			
Labor				
Total	\$1500			

*Heat exchanger, pump, and additional fluid circuit planned - \$500 additional (est.).

Performance:

50% off total PG & E bill. Carryover: 1 day for entire house and 3-5 days for living room.

Additional Info: Outer surface of storage tanks serves as heat exchanger from storage to forced-air heating system. Small insulated room built around storage. House air is drawn into room, picking up heat from outer surface of culvert sections, then into furnace and distribution ducts (so solar system also acts as preheater).

Source(s): Owner

BYL Residence/Sebastopol/Solar hot-water heating (\$40) May 1975

Retrofit/single-family residence/owner built/electric backup.
Free-standing tank-type collector/thermosiphon/water circulating/
with water storage.

Building: Added to existing residence.

System: Retrofit/HWH/tank-type collector/water circulating/with water storage. System built from 1936 publication "Solar Energy and Its Use for Heating Water in California"* by owner.

Collector: 32 ft² / tank-type in insulated box/single Tedlar glazing. Collector consists of 40-gal salvaged hot-water heater tank, with insulation removed and tank painted black, in insulated wood box with Tedlar glazing and moveable insulating cover.

Storage: 40-gal collector tank and existing hot-water heater.

Auxiliary: Electric hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 40	\$ 40		
Labor	\$ 0	\$ 0		
Total	\$ 40	\$ 40		

Performance: Preheats water for conventional hot-water heater. See Additional Info.

Additional Info: Extensive analysis of performance can be found in Ref. 1: F. A. Brooks, Solar Energy and Its Use for Heating Water in California, Bulletin 602, November 1936, College of Agriculture, University of California, Berkeley, California.

Source(s): Owner; Ref. 1

CRBT duplexes/Davis/Solar hot-water heating (\$1519 for two) March 1975

New construction/duplex/contractor built/gas backup/roof mounted tube-on-plate flat-plate collector/water circulating/with water storage.

Building: New/duplexes/1200 ft.² and 800 ft.². Wood-frame construction on slab floor. Part of a subdivision of solar-tempered houses with solar hot-water heating option, and optional solar space heating and cooling.

System: New/HWH/flat-plate collector/water circulating/thermosiphon/with water storage. System designed by Natural Heating Systems (Davis) and constructed by M. Corbett.

Collector: 100 ft.²/water-circulating flat plate/single glass glazing/ $\frac{1}{2}$ -in copper risers manifolded to $1\frac{1}{4}$ -in headers, soldered to 22-gauge galvanized steel sheet on 4-in centers. Collector built by Natural Heating Systems, Davis, CA.

Storage: 82-gal galvanized steel tank in peak of roof.

Auxiliary: Conventional 40-gal gas hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 1050			
Labor	\$ 469			
Total	\$ 1519			

Performance: Expected performance: 60% of heat for water heating.

Additional Info: Provides hot water for both duplexes: one three-bedroom one bath (1200 ft²) and one single-bedroom one bath (800 ft²). Duplexes are solar-tempered.

Source(s): John Hofacre (Natural Heating Systems, Davis, CA).

CSCS Energy Center/Rohnert Park/Solar heating and cooling (\$200) May 1975

New construction/classroom/student built/wood stove backup.
Passive-type system utilizing 60-deg south-facing wall with water-filled gallon jugs and moveable insulation.

Building: 515 ft.² Pole building oriented SSW built by students to code specification.

System: New/space heating and cooling/passive-type system/with south-facing bottle wall as collector and storage, moveable insulation and reflector. System designed by Barbara Greene and Roy Irving.

Collector: 220 ft.²/Bottle wall. 407 plastic milk bottles painted flat black and filled with water. Entire south wall is single glazed (panels are glazed with Kalwall, Tedlar, or 12-mil vinyl), oriented at 60 deg, south wall is collector. Insulated (2-in foam) doors with Mylar reflector opened daytime (for heating) and closed at night. Process reversed for cooling.

Storage: 407 gal water. Four 55-gal drums added in interior to moderate temperature fluctuations (65°F to 94°F in winter 1975-76), effectively doubling thermal mass.

Auxiliary: Woodstove. No auxiliary for cooling.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$200*			
Labor				
Total	\$200			

Performance: Measured since December 1975: interior temperature, exterior temperature and wind. Insolation. Data available. Cooling in summer 1975 "excellent." Winter heating very good though wide temperature fluctuations obtained until extra thermal mass added.

Additional Info: *Cost includes: bottles \$0; insulating doors, reflector, hardware, black paint - \$200 (figure includes some donated materials). In summer, thermal mass of wall moderates summer heat and cold foggy nights. Wall opened at night, closed during daytime in summertime; operates like Hay's system, to cool building.

Source(s): Barbara Greene and Roy Irving

CSEF Residence/Fetters hot springs/Solar hot-water heating (\$35) May 1975

Retrofit/single-family residence/owner built/electric backup.
Free-standing tank-type collector/thermosiphon/water
circulating/with water storage.

Building: Added to existing residence.

System: Retrofit/HWH/tank-type collector/water circulating/with water storage. System built from 1936 publication "Solar Energy and Its Use for Heating Water in California"* by owner.

Collector: 32 ft² / tank-type in insulated box/single Tedlar glazing. Collector consists of 40-gal salvaged hot-water heater tank, with insulation removed and tank painted black, in insulated wood box with Tedlar glazing and moveable insulating cover.

Storage: 40-gal collector tank and existing hot-water heater.

Auxiliary: Electric hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$35	\$35		
Labor	\$ 0	\$ 0		
Total	\$35	\$35		

Performance: Preheats water for conventional hot water heater. See Additional Info.

Additional Info: *For performance analysis, see Ref. 1:
F. A. Brooks, Solar Energy and Its Use for Heating Water in California, Bulletin 602, November 1936, College of Agriculture, University of California, Berkeley, California.

Source(s): Owner; Ref. 1

DFF Residence/Tomales/Solar hot-water heating (\$25) summer 1975

Retrofit (portable)/single-family residence/owner built/no backup.
Free-standing/flat-plate collector/thermosiphon/water circulating/
with water storage.

Building: Existing residence (rental).

System: New/HWH/flat-plate collector/water circulating/thermosiphon/
with water storage. System designed and built by owner.

Collector: 12 ft²/water-circulating flat plate/single fiberglass glazing.
Collector consists of recycled copper milk cooler (2ft x 6ft)
with fiberglass glazing panel, in insulated box.

Storage: 15-gal recycled hot-water tank.

Auxiliary: None.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$25	\$25	0	
Labor	\$ 0	\$ 0	0	
Total	\$25	\$25	0	

Performance: To 80^oF in "a couple of hours." Used for showers only.

Additional Info: All components of the system salvaged. The copper milk cooler was obtained from a scrapyard (\$25) and adapted as flat plate collector. System is transportable.

Source(s): Owner

DSCL/Davis/Solar space heating and cooling (\$35,000 for 1500 ft² building)
late 1976

New construction/school/contractor built/passive-type heating and cooling using south-facing glass wall with 21-in diameter water-filled steel tubes as collector and storage.

Building: School (1500 ft²).

System: Passive-type heating and cooling using south-facing glass wall with 21-in diameter water-filled steel tubes as collector and storage.

Collector: 250 ft²/passive type. Collector is south-facing windows with 21-in diameter water-filled tubes (steel and fiberglass) placed vertically. Single glass glazing.

Storage: 21-in diameter, steel-fiberglass tubes, water filled. Moveable insulation.

Auxiliary:

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

\$35,000 (estimated
total building
cost)

Performance:

Additional Info:

Source(s): J. Hammond (Living Systems, Winters, CA)

Ecology Action Office/Modesto/Solar hot-water heating (\$160) January 1976

Retrofit/office building/owner built/free-standing Roll-Bond/flat-plate collector/thermostat activated pump/water-circulating with water storage.

Building: Existing office building.

System: New/HWH/flat-plate collector/water circulating/thermostat activated pump/with water storage. Designed and built by office staff.

Collector: 24 ft²/water-circulating flat plate/double Tedlar glazing. Collector consists of a single aluminum Roll-Bond panel (3ft x 8ft) insulated with monotherm insulation, and double-glazed with Tedlar. A thermostat-activated pump circulates water from collector to storage when the collector water temperature exceeds storage water temperature by ten or more degrees F.

Storage: 80-gal storage tank (salvaged hot-water heater).

Auxiliary:

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$160	\$80	0	\$80
Labor	0	0	0	
Total	\$160	\$80	0	

Performance: Serves hot-water requirements of office.

Additional Info: Costs: Roll-Bond - \$40. Tedlar - \$40. Tank - free. Differential thermostat - \$10. Pump - #50. Fittings, etc. - \$20. Wood, other - free (recycled).

Source(s): Office of Ecology Action Educational Institute, Modesto, CA

Farallones Urban House/Berkeley/Solar hot-water heating (\$1058) August 1975

Retrofit/residence and classroom/built by staff/electric backup.
Roof mounted tube-on-plate flat-plate collector/thermosiphon/water circulating/with water storage.

Building: 3500 ft²/retrofit/two-story plus attic, separate residence converted into living, teaching, and research space.

System: Retrofit/HWH/flat-plate collector/water circulating/thermosiphon/with water storage. System designed and built by Scott Matthews and Doug Daniels.

Collector: 86.4 ft²/water-circulating flat plate/single glass glazing (PPG glass doors-seconds). Absorber plate is copper tube on copper sheet. Surface painted with black urethane aircraft paint.

Storage: 120-gal glass-lined steel tank.

Auxiliary: 30-gal electric hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$1058	\$203	\$855	
Labor				
Total	\$1058	\$203		

Performance: 90-95% estimated. 100% until February as auxiliary not installed until then. System performance is being monitored.

Additional Info: Orientation S 11^o E, freeze protection by means of heat tape activated by bimetallic thermostat.

Source(s): Doug Daniels, Philip Caesar, Scott Matthews (Farallones Institute).

FRLNS (Farallones Rural Center)/Occidental/Solar hot-water heating (\$100-\$200)
Fall 1975

New construction/bath house for school/owner built/wood-burning backup.
 Roof-mounted tank collector (breadbox)/water circulation/with water storage.

Building: New/bath house for school.

System: New/HWH/tank collector/water circulating/thermosiphon with water storage. System built from S. Baer design by students and instructors.

Collector: 32 ft²/tank-type collector/single glass glazing/reflector. Collector consists of a 130-gal tank in an insulated box, with glass glazing on top and south sides and insulated cover with reflector. Interior of box is lined with reflective foil.

Storage: Same 130-gal tank.

Auxiliary: Wood-burning stove with water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$100-\$200			
Labor				
Total	\$100-\$200			

Performance: Providing shower water for 12 people.

Additional Info: Built from Steve Baer "breadbox" design. Plans available from Baer.

Source(s): David Katz (Farallones Rural Center, Occidental, CA).

FRTR/Bodega Bay/Solar space heating (\$) May 1976

New construction/single-family residence/owner-contractor built/electric backup. Sandwich-type flat-plate collector/pumped/water circulating/with water storage. Integrated solar space heating and hot-water heating system.

Building: New/single-family residence/1650 ft². Four bedrooms, two baths, living room, dining room, kitchen.

System: New/HWH and SH/flat-plate collector/pumped/water circulating/with water storage. Heat distributed by radiant brick floor (ground level) and baseboard hot-water convective heaters (2nd floor). System designed by Bruce Corson.

Collector: 330 ft²/water-circulating flat plate/single glazing of Tedlar-coated fiberglas. Sandwich-type absorber plate consists of two sheets of galvanized sheet metal bolted together with neoprene gaskets and spacers. Collectors mounted on 42-deg south-facing roof.

Storage: 1000-gal concrete water tank.

Auxiliary: Franklin stove and two electric hot-water heaters (one for space heating and one for domestic hot water).

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: Estimated 75-80%.

Additional Info: Closed, low-pressure system (4 psi at base of collectors and 9 psi at tank). Circulating pump is 1/10 hp. Pumped freeze protection.

Source(s): Bruce Corson, Bodega Bay, CA

FRTR/Bodega Bay/Solar hot-water heating (\$) May 1976

New construction/single-family residence/owner-contractor built/electric backup. Sandwich-type flat-plate collector/pumped water circulating/with water storage. Integrated solar space heating and hot-water heating system.

- Building:** New/single-family residence/1650 ft². Four bedrooms, two baths, living room, dining room, kitchen.
- System:** New/HWH and SH/flat-plate collector/pumped/water circulating/with water storage. System designed by Bruce Corson.
- Collector:** 330 ft²/water-circulating flat plate/single glazing of Tedlar-coated fiberglas. Sandwich-type absorber plate consists of two sheets of galvanized sheet metal bolted together with neoprene gaskets and spacers. Collectors mounted on 42-deg south-facing roof.
- Storage:** Hot water preheated by heat exchanger in 1000-gal tank used for storage for solar space heating.
- Auxiliary:** 40-gal electric hot-water heater.
- | Cost: | Solar: | Collector: | Storage: | Aux./Other: |
|------------------|---------------|-------------------|-----------------|--------------------|
| Materials | | | | |
| Labor | | | | |
| Total | | | | |
- Performance:** Estimated 55-65% (preheating).
- Additional Info:** Closed, low-pressure system (4 psi at base of collectors and 9 psi at tank). Circulating pump is 1/10 hp. Pumped freeze protection.
- Source(s):** Bruce Corson, Bodega Bay, CA

FT/Napa/Solar hot-water heating (\$1400) December 1975

Retrofit/single-family residence/contractor built/electric backup.
copper tube-on-plate/flat-plate collector/thermosiphon/water
circulating/with water storage.

Building: Existing residence.

System: Retrofit/HWH/flat-plate collector/water circulating/with
water storage. System designed and built by Gary Gerber
and John Vail of Interactive Resources, Inc.

Collector: 50 ft²/water-circulating flat plate/glazed with clear glass
tubes (fluorescent light tubes). Collector plate is copper
tube on copper plate.

Storage: 100-gal hot-water heater tank.

Auxiliary: Standard electric water heater (100 gal) with bottom element
removed.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 550	\$ 250	existing	\$ 300
Labor	\$ 850	\$ 300		\$ 550
Total	\$ 1400	\$ 550		\$ 850

Performance:

Additional Info:

Source(s): Gary Gerber (Interactive Resources, Inc., Point Richmond, CA)

GDE/Sonoma/Solar hot-water heating (\$1240) Summer 1976

New construction/single-family residence/contractor built/electric backup.
 Tube-on-plate/flat-plate collector/pumped water circulating/with water storage.

Building: New/single-family residence/about 1800 ft².

System: New/HWH/flat-plate collector/water circulating/with water storage. System designed by Interactive Resources, Inc.

Collector: 40 ft²/water-circulating flat plate/single Filon glazing. Absorber plate is copper tube on aluminum (Sunburst).

Storage: 120-gal hot-water heater (bottom element disconnected).

Auxiliary: 120-gal hot-water heater (same as storage).

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 560	\$ 160	\$ 400	
Labor	\$ 680	\$ 80	\$ 600	
Total	\$ 1240	\$ 240	\$ 1000*	

Performance:

Additional Info: *Fees for entire design work (space heating and hot-water heating) were \$800 additional.

Source(s): Dale Sartor (Interactive Resources, Inc., Point Richmond, CA).

GDE/Sonoma/Solar space heating (\$6080) Summer 1976

New construction/single-family residence/contractor built/electric backup.
Tube-on-plate/flat-plate collector/pumped water circulating/with water storage.

Building: New/single-family residence/about 1800 ft²..

System: New/space heating/flat-plate collector/water circulating/
with water storage. System designed by Interactive Resources,
Inc.

Collector: 360 ft²/water-circulating flat plate/single Filon glazing.
Absorber plate is copper tube on aluminum fins (Sunburst).

Storage: 1500-gal precast concrete tank (septic tank) insulated
with 3-in foam (R=26).

Auxiliary: Wood stove. Electric resistance heating (forced-air furnace).

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$3040	\$1440	\$500	\$1100
Labor	\$3040	\$1440		
Total	\$6080	\$2880		\$1600

Performance:

Additional Info: Fees for entire design work (space heating and hot-water heating) were \$800 additional.

Source(s): Dale Sartor (Interactive Resources, Inc, Point Richmond, CA)

GMBL/Petaluma/Solar space heating (\$1600) Winter 1974-75

Retrofit/greenhouse added to residence/owner built/backup not specified.
Flat-plate collectors (Fafco brand)/water circulated by pumps/water storage/heat distributed by radiant baseboard heater.

Building: Retrofit/greenhouse added to existing residence.

System: Retrofit/space heating/flat-plate collector/water circulating/water storage/with heat distributed by radiant baseboard heater.

Collector: 300 ft²/water-circulating flat plate/single glazed with single 4-mil polyethylene glazing. Collector consists of Fafco brand panels. Glazing material installed as temporary.

Storage: 4000 gal (4 x 8 x 20ft) water storage tank, built of plywood with 3-in Styrofoam insulation.

Auxiliary: Not specified.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$1600		\$300	
Labor				
Total	\$1600			

Performance: Estimates 300,000 Btu/day.

Additional Info: Hot water from collector is pumped to storage, then pumped to radiant baseboard heater when desired.

Source(s): Owner

GRBR/Walnut Creek/Solar hot-water heating (\$1000) November 1975

Retrofit/single-family residence/contractor built/gas and electric backup/
tube-on-plate flat-plate collector/pumped/water circulating with water
storage.

Building: Retrofit/single-family residence.

System: Retrofit/HWH/flat-plate collector/water circulating/pumped/
with water storage. System designed and built by Gary Gerber
and John Vail.

Collector: 50 ft²/water-circulating flat-plate collector/glazing is clear
glass tubes (fluorescent light type). Absorber plate is copper
tube on copper plate.

Storage: 60-gal (uses existing hot-water heaters for storage).

Auxiliary: 40-gal gas water heater and 20-gal electric water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
				see storage
Materials	\$ 550	\$200	\$200	\$150
Labor	\$ 450	\$200	\$100	\$150
Total	\$ 1000	\$400	\$300	\$300

Performance:

Additional Info: Note double use of Auxiliary and Storage

Source(s): Gary Gerber (Interactive Resources, Inc., Point Richmond, CA)

GSPS Residence/Tomales/Solar space heating (\$150/\$500)

Retrofit/single-family residence/owner built/added south-facing greenhouse with passive-type system (bottle wall) using water-filled jugs as collector and storage. Heat enters house through ducts located at top of greenhouse.

Building: Retrofit/single-family residence.

System: Retrofit/space heating/passive-type system (bottle wall) using south-facing greenhouse addition with water-filled jugs and moveable insulation.

Collector: Approximately 120 ft²/passive-type south-facing bottle wall in lean-to greenhouse with single glazing of corrugated fiberglass panels and moveable insulation.

Storage: Water-filled jugs.

Auxiliary:

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$150			
Labor	\$350			
Total	\$500			

Performance: Heated greenhouse area vents at top into the house.

Additional Info: Construction funded by Point Foundation of San Francisco.

Source(s): Independent Journal (newspaper) of Marin.

Hay (Skytherm)/Solar space heating and cooling (\$) 1973

New construction/single-family residence/contractor built/passive system using water-filled plastic bags on roof with moveable, insulated panels/integrated collector, storage, distribution system.

Building: New/single-family residence/1140 ft²/one-story/oriented E-W/ exterior and partition walls of concrete blocks, interior filled with sand and exterior with vermiculite. Total cost of building (prototype) was \$39,500.

System: New/SH and SC/passive-type system/water-filled plastic bags on roof/moveable, insulated panels/metal roof acts as ceiling, radiating (winter) or absorbing (summer) heat from interior.

Collector: 1200 ft²/passive-type system/9 in. of water in four transparent plastic (PVC) bags lying on metal roof between extruded aluminum tracks/ insulated panels move in tracks above bags/panels moved automatically by ¼-hp motor and chain-drive. Single "glazing" of PVC plastic sheet inflated above bags in winter, not in summer. Black PVC plastic sheet between bags and metal roof. Roof (ceiling) is ribbed steel, with 12-ft spans.

Storage: 6300 gal (26 tons) of water in plastic bags on roof/thermal mass of house provides additional storage.

Auxiliary: None

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: Allowing for moderate temperature fluctuation, system provided 100% of required heating and cooling during 1973-1974. Performance evaluated by Cal Poly, San Luis Obispo.

Additional Info: Winter: bags uncovered during day/sun heats water/ bags covered at night to retain heat/ceiling (roof) radiates heat to interior. Summer: bags uncovered at night/cool night air and sky cools water/bags covered during day/ cool ceiling absorbs interior heat.

Source(s): Shurcliff (Ref. 2)

HCHC/Chico/Solar hot-water heating (\$1000 estimated) Late 1976

New construction/single-family residence/contractor built/electric backup. Flat-plate collector/water circulating/thermosiphon/with water storage.

Building: New/single-family residence/1600 ft².

System:

Collector: 70 ft²

Storage: 80 gal

Auxiliary: Electric hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
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Materials

Labor

Total \$1000 (estimated)

Performance:

Additional Info: \$40,000 estimated cost for house.

Source(s): John Hammond (Living Systems, Winters, CA)

HCHC/Chico/Solar space heating and cooling (\$4000 estimated) Late 1976

New construction/single-family residence/contractor built/wood backup.
Passive-type system using south-facing windows with moveable insulation and 21-in diameter steel tubes (water-filled) for storage.

Building: New/single-family residence/1600 ft².

System: New/space heating and cooling/passive-type system using south-facing windows as collector, with moveable insulation and water-filled metal tubes for storage. System designed by Living Systems, Winters, CA.

Collector: Passive-type/about 300 ft² of south-facing windows with moveable insulation.

Storage: About 1000 gal of water in 21-in diameter galvanized steel culvert sections.

Auxiliary: Woodstove.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$4000 (estimated)

Performance: Not completed.

Additional Info: \$40,000 estimated for house.

Source(s): John Hammond (Living Systems, Winters, CA)

Hewlett-Packard Plant/Sunnyvale/Solar space heating (\$18,000) Fall 1973

Retrofit/165,000-ft² industrial plant/built by plant maintenance personnel/gas backup. Roof-mounted flat-plate collectors (7000 ft²) retrofitted to existing terminal-reheat system. Pumped water circulating with water storage.

Building: Retrofit to existing industrial plant/165,000 ft². Collectors are mounted on flat roof of the building.

System: Retrofit/space heating/roof-mounted flat-plate collectors/pumped water circulating to storage/heat distributed by existing terminal-reheat system. System designed by Mac McFee, Plant Facilities Manager, Hewlett-Packard.

Collector: 7000 ft²/flat-plate collector/single glazing of Tedlar-coated fiberglass (Filon Weatherside 548). Collectors (8ft x 33 in) are wood-framed aluminum Roll-Bond panels, with 1-in Celotex insulation, connected in series with CPVC plastic pipe.

Storage: 12,000-gal steel tank (used oil-storage tank) buried underground (uninsulated). Plan to add 50,000 gal additional storage.

Auxiliary: Existing gas-fired boiler.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$18,000			
Labor				
Total	\$18,000			

Performance: Gas savings are \$1000 - \$2000 per month as determined from gas bills. Data on gas consumption (1972 - 1976) available from Mac McFee.

Additional Info: System constructed by plant maintenance personnel as "low priority task," collector components purchased at lower bulk-purchase rate. Existing system adjusted to operate at 120°F.

Source(s): Marshal Merriam (U.C. Berkeley); Mac McFee (Hewlett-Packard, Sunnyvale, CA).

HFCR/Davis/Solar space heating and cooling (estimate < \$1,000)* September 1976

New construction/single-family residence/owner-contractor built/gas backup/passive system utilizing south-facing windows with 50-gal water-filled drums, slab floor for storage, and moveable, insulating shutters.

Building: New/single-family residence/1169 ft². Wood-frame construction on slab floor. Part of a subdivision of solar-tempered houses with solar hot-water heating option. Contractor - M. Corbett.

System: New/space heating and cooling/passive-type system with water (water-filled 50-gal drums) and concrete (slab floor) storage. System designed by J. Hofacre, built by M. Corbett with owner.

Collector: 162 ft²/passive-type system with two south-facing patio doors (12 ft x 6 ³/₄ ft each) and 20 water-filled 50-gal drums. Collector windows will have insulated (moveable) shutters or double glass glazing.

Partially owner-built/partially contractor-built (M. Corbett).

Storage: 20 water-filled 50-gal drums (estimated 40,000 Btu capacity), plus exposed slab floor and interior partition thermal mass (estimated 50,000-Btu capacity).

Auxiliary: 55,000/Btu/hr forced-air gas furnace and Franklin fireplace (heating). No auxiliary cooling unit.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total (estimate less
 than \$1000)*

Performance:

Additional Info: Located at 38° north latitude. Residence has seven rooms: three bedrooms, one bath, kitchen, living room, dining room
*Costs for system (drums, insulated shutters) not yet determined.

Source(s): John Hofacre (Natural Heating Systems, Davis, CA)

HFCR/Davis/Solar hot-water heating (\$) September 1976

New construction/single-family residence/contractor built/ gas backup/
roof-mounted flat-plate collector/thermosiphon/water circulating/with
water storage.

Building: New/single-family residence/1169 ft². Wood-frame construction on slab floor. Part of a subdivision of solar-tempered houses with solar hot-water heating option, and optional solar space heating and cooling.

System: New/HWH/flat-plate collector/water circulating/thermosiphon/with water storage. System designed by J. Hofacre, built by M. Corbett (with owner).

Collector: 80 ft²/water-circulating flat plate/single Kalwall brand glazing. Sunburst panels glazed with single layer of Kalwall roll fiberglass.

Collector built by Natural Heating Systems, Davis, CA.

Storage: 82-gal storage tank in attic.

Auxiliary: 40-gal gas hot-water heater.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance:

Additional Info: System provides preheated (solar-heated) water, from 82-gal storage tank to conventional heater, which may be bypassed.

Source(s): John Hofacre (Natural Heating Systems, Davis, CA)

HMND/Winters/Solar space heating and cooling (\$500) Summer 1974

Retrofit/single-family residence/owner built/gas and wood backup. Passive-type system/south wall, water-filled 55-gal drums inside vertical window wall/with moveable insulation.

Building: Retrofit/single-family residence/1200 ft². Remodeled farmhouse, frame construction with slab floor.

System: Passive-type system. Water-filled drums inside south-facing window-wall collect and store heat during daytime, radiating heat to house at night. Same drums moderate summer heat by using thermal mass and night sky radiation. System designed by Living Systems, Winters, CA.

Collector: 200 ft²/passive-type system utilizing water-filled 55-gal drums inside vertical, south-facing (single-glazed glass) windows. Moveable insulation (sliding panels) consists of three layers of reflective foil.

Storage: 15,000 lbs water in 55-gal drums (32). Also slab floor.

Auxiliary: Gas stove and wood-burning stove.

Cost: Solar: Collector: Storage: Aux./Other:

Materials \$500 (approx)

Labor

Total \$500

Performance: Woodstove, only backup, required ½ cord wood in winter of 1974 - 1975 and ¼ cord wood in 1975 - 1976.

Additional Info: House also has solar hot-water heater (50 ft² flat-plate collector with 80-gal storage tank).

Source(s): John Hammond (Living Systems, Winters, CA)

HNMN/Sunnyvale/Solar space and hot-water heating (\$) October 1975

Retrofit/single-family residence/contractor built/gas backup. Tube-in-plate flat-plate collector/pumped/water circulating/with water storage. Integrated space heating and hot-water heating system.

Building: Retrofit/single-family residence/2000 ft²/oriented E-W (an Eichler home).

System: Retrofit/SH and HWH/flat-plate collector/pumped/water (with additives*) circulating/with water storage. System is integrated with existing radiant floor-heating system/fully automatic controls (except for auxiliary). System designed and built by Alten Associates, Santa Clara, CA.

Collector: 350 ft²/water circulating/flat plate/double glazing of Tedlar/R-11 foil-backed insulation. Absorber is Olin Brass Company Roll-Bond aluminum plate. Collectors mounted on and integrate well with existing roof.

Storage: 1000-gal steel tank/two-thirds below ground/storage water doesn't circulate: three heat-exchangers in tank, one from collectors, one for space heating, and one for domestic hot water.

Auxiliary: Regular gas furnace and hot-water heater/intentionally manually controlled.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: 60% of heating.

Additional Info: *Closed collector fluid loop containing water, corrosion inhibitors, antifreeze solution. CPVC pipe and Al heat exchanger used - no Cu in system. 1/200-hp pump for domestic hot-water system, 1/6 hp pumps for space heating and domestic hot-water systems.

Source(s): Klaus Heinemann (Alten Associates, Santa Clara, CA)

HSR - MFR/Davis/Solar hot-water heating (\$950) April 1976

New construction/single-family residence/contractor built/gas backup.
Roof-mounted tube-on-plate/flat-plate collector/thermosiphon.
Water circulating/with water storage.

Building: New single-family residence/1157 ft². Wood-frame construction on slab floor. Part of a subdivision of solar-tempered houses with solar hot-water heating option, and optional solar space heating and cooling.

System: New/HWH/flat-plate collector/water circulating/thermosiphon/with water storage. System designed by J. Hofacre, built by M. Corbett.

Collector: 60 ft²/water-circulating flat plate/single glass glazing/½-in copper risers manifolded to 1¼-in headers, soldered to 22-gauge galvanized steel sheet on 4-in centers. Collector built by Natural Heating Systems, Davis, CA.

Storage: 82-gal galvanized storage tank located in attic.

Auxiliary: 40-gal gas water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$627 (est)			
Labor	\$323 (est)			
Total	\$950 (est)			

Performance: 70% load estimated.

Additional Info: 38.5° north latitude.

Source(s): John Hofacre (Natural Heating Systems, Davis, CA)

HTN/Berkeley/Solar space heating (\$900)

Retrofit/duplex residence and office/owner built/gas backup.
Roof-mounted trickle-type collector/pumped/water circulating/
with water storage.

Building: Two-story duplex residence and office/2100 ft². Flat roof. Built in 1910.

System: Retrofit/space heating/trickle-type collector/pumped/water circulating/with water storage.

Collector: 288 ft² (12 ft x 24 ft)/water type/trickle system. Corrugated aluminum sheet (aluminum siding from Montgomery Ward) used for absorber plate/coated with flat black paint. Collector was originally single glazed (glass). Now testing various types and combinations of glazing.

Storage: Seven 55-gal steel drums (385 gal total) filled with water.

Auxiliary: Gas furnace.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$900	\$2/ft (\$580)		
Labor	(200 hrs)			
Total				

Performance: 58% of heating

Additional Info: Steel drums used for storage are connected by PVC plumbing and hose connections. Surfaces of drums act as heat exchanger. Furnace blower draws cooled return air through the room containing the drums and into the ducts of the regular forced-air heating system.

Source(s): Owner

IRIS Images/Mill Valley/Solar hot-water heating (\$11,240) April 1976

Retrofit/commercial: film processing/contractor built/gas backup.
Roof-mounted tube-on-plate/flat-plate collector/pumped water
circulating/with water storage. Designed to provide large quantity
of 100-deg hot water for immediate daytime use in film processing.

Building: Commercial building/5000 ft².

System: New/HWH/flat-plate collector/pumped water circulating with
water storage. System designed and built by Interactive Resources, Inc.

Collector: 640 ft²/flat-plate collector/single Filon glazing. Absorber
plate is tube-on-plate (Sunburst). Collector pressurized
at city water pressure.

Storage: 360-gal insulated storage tank.

Auxiliary: Gas hot-water heater.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$11,240

Performance: System designed for commercial film processing to provide
a peak load of 12 gal per minute at 100° F and average
load of 6 gal per minute.

Additional Info: Roof mounting required extra support structure (\$3000)
to support weight, plus construction management fee.

Source(s): Dale Sartor (Interactive Resources, Inc., Pt. Richmond, CA)

IRVG Residence/Cotati (Sonoma County)/Solar hot-water heating (\$40) October 1974

Retrofit/mobile home/owner built/flat-plate collector/electric backup/
thermosiphon/water circulating with water storage.

Building: Retrofit/mobile home/about 350 ft².

System: New/HWH/flat-plate collector/water circulating (thermosiphon)
with water storage. System designed and built by owner.

Collector: 15 ft²/flat-plate collector/with single glazing (Tedlar).
Collector consists of copper tubing, wired and soldered
to metal plate in fiberglas insulated box. Tilt is
adjustable with seasons.

Storage: Standard 20-gal water heater tank.

Auxiliary: Electric water heater (used in winter only: solar is only
summer heat source).

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$45	0	0	
Labor	0	0	0	
Total	\$45	\$45	0	

Performance: 50% needs in winter (November 1 - May 1); 100% needs in summer
(May 1 - November 1). Household consists of one person. Two
years of performance data available.

Additional Info: System uses existing electric hot-water heater as storage
and supplement - electric heater operates only when in-
sufficient solar hot water. In summer, electric heater
completely shut off (all hot water provided by solar
collector).

Source(s): Owner

ISC (Champion Homebuilders)/Various locations/Solar heating and cooling (\$2600:96 ft², \$3140:128 ft², \$3780:160 ft²) 200+ units

Modular mass-produced solar heating and cooling unit. Freestanding/air collector/with rock storage/attaches to forced air heating and cooling systems of existing or new structures.

Building: Reportedly over 200 have been sold for houses and mobile homes. Several houses in operation in California (San Jose, Napa).

System: Freestanding A-frame unit/air circulating/fans/with rock storage. Heat stored in rocks by circulating air is removed from storage to house interior as needed. Cooling: process is reversed, cooling rocks with night air and closing collector.

Collector: 96, 128, and 160 ft² models available/air-circulating flat plate/fans/double glazing of glass/reflector. Collector tilted 60 degrees on south face of A-frame structure. Aluminum absorber plate has open cylinders to divert air flow.

Storage: Rock storage (river bed rock must be obtained locally to specifications) cubic feet capacity is 225,310, and 400, respectively.

Auxiliary: Various. Most easily integrated with forced air systems, either existing (retrofit) or new. Adaptable to other supplementary heating and cooling systems.

Cost:	Solar:	Collector:	Storage:	Aux./Othe:
Materials (Whole unit):	(96 ft ²) \$2600	(128 ft ²) \$3140	(160 ft ²) \$3780	
Labor (Installation)	<u>500</u>	<u>550</u>	<u>600</u>	
Total	\$3100	\$3690	\$4380	

Performance: System has been tested by Midwest Engineering Service, Inc., Denver, Colorado. See "Sources."

Additional Info:

Source(s): Alternative Energy Co., Yountville, CA; Manufacturer's Literature; "Harnessing the Sun to Heat Your House", by J. H. Keyes.

JFFR/Kentfield/Solar space heating () November 1975

New construction/single-family residence/contractor built/gas backup.
Roof-mounted trickle-type collector/water circulating/pumped with
water storage.

Building: New/single-family residence/2300 ft². South-facing three-story house/insulation - walls (R-13) and ceiling (R-22)/double-glazed windows/oriented due south.

System: New/space heating/trickle-type collector/water circulating/thermostat-controlled pump/with water storage. System designed by Interactive Resources, Inc., Richmond, CA.

Collector: 900 ft²/trickle type/30-deg slope glazing of planar array of air-filled clear glass tubes (fluorescent-type). Absorber plate is corrugated aluminum sheet with black enamel surface. Fluid is softened water with no antifreeze or corrosion inhibitors. Controllable-rate (0 to 20 gpm) 3/4-hp pump feeds water to horizontal distribution pipe along top of collector.

Storage: 3000-gal rectangular (8½ ft x 8½ ft x 8 ft high) concrete tank in crawl space/R-27 foam insulation. 1/20-hp pump circulates hot water to two fan-coil systems.

Auxiliary: Gas-fired hot-water heater.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: 85% (predicted). Carry through: 3½ days (predicted).

Additional Info: Cooling: structure designed to exclude south summer sun/west windows of reflective glass/natural venting due to shape, with fan assist.

Source(s): Shurcliff (Ref. 2); Dale Sartor (Interactive Resources, Inc., Pt. Richmond, CA)

JFFR/Kentfield/Solar hot-water heating (\$1200) March 1976

New construction/single-family residence/contractor built/electric backup. Roof-mounted flat-plate collector/water circulating/with water storage.

Building: New/single-family residence/2300 ft².

System: New/HWH/flat-plate collector/water-circulating/with water storage. System designed and built by Gary Gerber and John Vail of Interactive Resources, Inc.

Collector: 54 ft²/water-circulating flat plate/glazed with fluorescent tubes. Collector plate is copper tube on copper plate.

Storage: 100-gal electric hot water heater tank.

Auxiliary: Electric water heater (storage and auxiliary).

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$700	\$250	\$250*	\$200
Labor	\$500	\$200	\$ 0	\$300
Total	\$1200	\$450	\$250	\$500

Performance:

Additional Info: *See Shurcliff (Ref. 1)

Source(s): Gary Gerber. (Interactive Resources, Inc., Pt. Richmond, CA)

LKS/Sacramento/Solar space heating and cooling and hot-water heating
 (\$) July 1976

New construction/single-family residence/owner built/combo passive-type system (south-facing Thermopane windows with concrete slab floor storage) and active-type system (air-type collector with rock storage). Separate water-circulating flat-plate collector with water storage for domestic hot water.

Building: New/single-family residence/about 1752 ft²/wood-frame construction/concrete slab floor. Oriented 15-deg west of south.

System: New/SH and SC/combo passive system (south-facing, Thermopane-glazed windows with concrete slab floor storage) and active system (air-circulating collector with rock storage). Separate water-circulating flat plate with water storage for domestic hot water.

Collector: Active: 400 ft²/air-circulating flat-plate collector/sheet metal absorbers/double glazed with (Kalwall) fiberglas.
 Passive: 240 ft²/south-facing windows/Thermopane glazing.
 Hot water: water-circulating flat plate.

Storage: 45 tons of 2-in-diameter river rock/20 ft x 8 ft high x 5 ft concrete-block storage bin/located in house. Concrete slab floor provides additional thermal mass. 50-gal hot-water heater storage.

Auxiliary: Forced-air furnace/air conditioner.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: 70% (est.)

Additional Info: Estimated completion date - July 1976. Rocks in storage bin will be cooled at night during summer to provide daytime cooling.

Source(s): Owner

New construction/duplex/contractor built/gas backup/passive-type system utilizing south-facing windows and skylight with slab floor for storage and moveable insulation (shutters).

Building: New/duplex/1157 ft² plus 100 ft² loft. Wood-frame construction on slab floor. Part of a subdivision of solar-tempered houses with solar hot-water heating option: Contractor - M. Corbett.

System: New/space heating and cooling/passive-type system/with concrete (slab floor) storage.

Collector: 155 ft²/passive-type system/single glass glazing/with two sliding glass doors, 6³/₄ x 12 ft and 6³/₄ x 8 ft on south wall, one skylight 4 x 5 ft at 60-deg inclination on south-facing roof. Slab floor serves as heat collector and storage, moveable insulating shutters to be added.

Storage: 1157 ft² slab floor, interior brick wall, possible added thermal mass.

Auxiliary: 60,000 Btu forced-air gas furnace (\$400 - \$600). No cooling backup considered necessary.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

\$400 - \$600*
estimated

Performance: Currently being monitored. Thermocouples imbedded in walls, also slab floor between parquet and slab, between slab and gravel, below gravel.

Additional Info: Insulation: R-19 wall, R-25 roof.

*Cost estimate is for moveable insulation on south-facing glass skylight and doors.

Source(s): Owner; John Hofacre (Natural Heating Systems, Davis, CA)

LNDQT Residence/Davis/Solar hot-water heating (\$950) March 1976

New construction/duplex/contractor built/gas backup/roof-mounted copper tube-on-plate/flat-plate collector/thermosiphon/water circulating/with water storage.

- Building:** New/duplex/1157 ft² plus 100 ft² loft. Wood-frame construction on slab floor. Part of a subdivision of solar-tempered houses with solar hot-water heating option: Contractor - M. Corbett.
- System:** New/HWH/flat-plate collector/water circulating/thermosiphon with water storage. System designed by Natural Heating Systems, built by M. Corbett.
- Collector:** 60 ft²/water-circulating flat plate/single glass glazing/ $\frac{1}{2}$ -in copper risers manifolded to $1\frac{1}{4}$ -in headers, soldered to 22-gauge galvanized steel sheet on 4-in centers. Collector designed and built by Natural Heating Systems, Davis, CA.
- Storage:** 82-gal storage tank in attic.
- Auxiliary:** 40-gal gas water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$627			
Labor	\$323			
Total	\$950			

Performance: Anticipate 80% of hot water provided by solar. Currently being monitored in detail by UC Davis ME department and designers, particularly for reverse thermosiphon effect.

Additional Info: 82-gal storage tank provides make-up water to conventional heater which can be bypassed. Home cost less than \$35,000 total.

Source(s): John Hofacre (Natural Heating Systems, Davis, CA)

MCF/San Jose/Solar space heating (\$2100) May 1975

Retrofit/single family residence/owner built/gas backup. Integrated system for space heating, hot water heating and heating of swimming pool. System uses one set of collectors and a single storage tank, with three separate heat exchangers.

Building: Retrofit/single family residence/2100 ft². Two-story, wood-frame construction, oriented south.

System: Retrofit/space heating and hot water heating/pumped water-circulating to storage/heat exchanger in storage tank transfers, heat to space heating system.

Collector: 533 ft²/water-circulating flat plate collector/single Tedlar-coated fiberglass glazing. Collector panels are Rollbond panels (aluminum) framed with 1" x 2"s, and insulated with two layers of 1/2" insulating board. Collectors located on roof.

Storage: Heat exchanger in 1,000 gallon water storage tank located in garage. Tank is insulated with styrofoam pellets (2" on sides, and 6" on top.)

Auxiliary: Gas (forced air) furnace. (80,000 BTU)

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 2100	\$ 1,128	\$ 200	\$ 110
Labor	-	-	-	-
Total	\$ 2100	\$ 1,128	\$ 200	\$ 110

Performance: Estimate 55% space heating needs provided in December and January, and 80% - 85% rest of the year.

Additional Info: Heated water delivered from collectors is stored in rectangular tank located in garage. Three separate heat exchangers located in storage tank provide heat for 1) space heating 2) hot water heating 3) swimming pool.

Source(s): Owner

Retrofit/single family residence/owner built/gas backup. Integrated system for space heating, hot water heating, and heating of swimming pool. System uses one set of collectors and a single storage tank, with three separate heat exchangers.

Building: Retrofit/single family residence/2100 ft². Two-story, wood frame construction, oriented south.

System: Retrofit/space heating and hot water heating/pumped water-circulating to storage/heat exchanger in storage transfers heat to hot water tank.

Collector: 533 ft²/water circulating flat plate/single, Tedlar-coated fiberglass glazing. Collector panels are Rollbond panels (aluminum) framed with 1" x 2"s, and insulated with two layers of 1/2" insulating board. Collectors located on roof.

Storage: Heat exchanger in 1,000 gallon water storage tank located in garage. Tank is insulated with styrofoam pellets (2" on sides and 6" on top.)

Auxiliary: Gas hot water heater. (30 gallon)

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 2100	\$ 1,128	\$ 200	\$ 110
Labor	-	-	-	-
Total	\$ 2100	\$ 1,128	\$ 200	\$ 110

Performance: Estimate 85% hot water needs provided (to 100% in summer.)

Additional Info: Heated water delivered from collectors is stored in rectangular tank located in garage. Three separate heat exchangers located in storage tank provide heat for 1) space heating 2) hot water heating 3) swimming pool.

Source(s): Owner.

New/single-family residence/contractor built/electric backup.
Roof-mounted flat-plate collector/pumped water circulating/with
water storage. Integrated solar system for spacing heating, space
cooling, and hot-water heating (heat exchange in storage tank).

Building: *New/single-family residence/3600 ft². Two-story house with basement.

System: *New/integrated system for space heating, space cooling, and hot water heating. Water is circulated through the collector when collector temperature is high enough to add energy to Tank A or low enough to extract energy from Tank B. Domestic hot water preheated by copper heat exchanger in Tank A. System designed by J. Schultz of Solar Utilities, Co.

Collector: *500 ft²/tube-on-plate flat-plate collector/single glazing of Tedlar-coated fiberglass. Collector consists of one large panel (36 ft x 14 ft) with black-coated aluminum absorber plate, and an array of parallel, 5/8-in diameter stainless steel tubes (or 1/2-in diameter copper tubes) affixed to plate with Thermon conductive cement, on 5-in centers.

Storage: Two 1200-gal concrete tanks (water-filled) located underground and insulated by 1 1/2 ft of gravel. Tank A stores hot water for space heating and domestic hot water; Tank B stores cold water for space cooling.

Auxiliary: 3-ton heat pump, 40-gal electric hot-water heater.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: Estimate 70-80% solar heating.

Additional Info: For heating, blower blows air through coil fed with hot water from Tank A. For summer cooling, blower blows air through coil fed with cold water from Tank B. See Ref. 2.

Source(s): Shurcliff (Ref. 2)

New construction/single-family residence/owner built/electric backup. Passive-type system with double-glazed south-facing windows and slab floor, moveable insulating shutters. Greenhouses on east and west of house, north exposure bermed (wine cellar).

Building: New/single-family residence/900 ft². Greenhouses on east and west of house, north wall bermed (wine cellar).

System: New/space heating and cooling/passive-type system (south-facing double-glazed windows with insulated shutters, and slab floor). Flat-plate system may be added later (if necessary).*

Collector: 192 ft²/passive-type system with south-facing windows (12 ft x 16 ft) and slab floor/double-glass glazing (Thermopane). Collector windows have insulated shutters. Greenhouses on east wall and west of house contribute to solar heating.

Storage: Concrete slab floor dyed red-brown.

Auxiliary: Wood burning, electric resistance.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$400			
Labor	\$ 0			
Total	\$400			

Performance:

Additional Info: *Active solar heating system may be added later: 400-ft² flat-plate collectors, 1500-gal concrete storage tank. (Estimated cost - \$3000 for materials.)

Source(s): Dale Sartor. (Interactive Resources, Inc., Pt. Richmond, CA)

NHSR/Occidental (Sonoma County)/Solar hot-water heating (\$600) May 1976

New construction/single-family residence/owner built/electric backup.
Tube-on-plate flat-plate collector/water circulating/with water storage.

Building: New/single-family residence/900 ft². Building designed by Interactive Resources, Inc.

System: New/HWH/flat-plate collector/water circulating/with water storage. System designed by Interactive Resources, Richmond, CA.

Collector: 40 ft²/water-circulating flat plate/single glazing. Absorber plate consists of copper tubes on aluminum fins.

Storage: 120-gal hot-water tank.

Auxiliary: 120-gal electric hot-water heater with bottom element removed.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$600			
Labor	\$ 0			
Total	\$600			

Performance:

Additional Info:

Source(s): Dale Sartor (Interactive Resources, Inc., Pt. Richmond, CA)

RDBS Residence/Sausalito/Solar hot-water heating (\$930) April 1976

New construction/single-family residence/owner and contractor built/gas backup. Combined space and hot water heating. Tube-on-plate flat-plate collector/pumped water circulating/with water storage.

Building: New/single-family residence/2300 ft².

System: New/SH and HWH/pumped water circulating with water storage. System designed and built by Interactive Resources, Inc., with owner.

Collector: 80 ft²/water-circulating flat plate
Absorber plate is copper tube on aluminum fins (Sunburst).

Storage: 120-gal insulated tank.

Auxiliary: Gas hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$930	\$400	\$170	\$360
Labor				
Total				

Performance:

Additional Info: Partially owner-built and partially contracted: labor estimates are for system if entirely contracted (no owner participation).
Labor: 52 skilled man-hours

Source(s): Dale Sartor (Interactive Resources, Inc., Pt. Richmond, CA)

RDBS/Sausalito/Solar space heating (\$4160) April 1976

New construction/single-family residence/owner and contractor built/
gas backup. Space and hot-water heating. Tube-on-plate flat-plate
collector/pumped water circulating/with water storage.

Building: New/single-family residence/2300 ft².

System: New/SH and HWH/flat-plate collector/pumped water circulating
with water storage. System designed and built by Interactive
Resources, Inc., with owner.

Collector: 640 ft²/water-circulating flat plate. Absorber plate is
copper tube on aluminum fins (Sunburst).

Storage: 4000-gal cast-in-place concrete tank, 3-in foam (R-26)
insulation and Hypalon lining.

Auxiliary:

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$4160	\$2560	\$500	\$1100
Labor				
Total				

Performance:

Additional Info: *Approximately 208 man-hours (skilled labor).

Source(s): Dale Srtor (Interactive Resources, Inc., Pt. Richmond, CA)

RTN Residence/Davis/Solar hot-water heating (\$1500) December 1975

New construction/single-family residence/contractor built/electric backup.
Tube-on-plate flat-plate collector/thermosiphon/water circulating with
water/with water storage.

Building: New/single-family residence/3076 ft² (12 rooms).
Solar-tempered building - M. Corbett, Contractor.

System: New/HWH/flat-plate collector/water circulating/thermosiphon/
with water storage. System designed by Natural Heating
Systems, Davis, CA.

Collector: 100 ft²/water-circulating flat plate/single glass glazing
½-in copper risers bonded to 22-gauge steel plate on
4-in centers.

Storage: 82-gal galvanized steel tank.

Auxiliary: Two 40-gal electric hot-water heaters.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$1066			
Labor	\$ 434			
Total	\$1500			

Performance: 80% estimated.

Additional Info: Solar-tempered residence.

Source(s): John Hofacre and Dave Springer (Natural Heating Systems, Davis, CA)

RYN Residence/Jenner (Sonoma County)/Solar space heating (\$) August 1976

New construction/single-family residence/contractor built/electric backup.
Free-standing Roll-Bond flat-plate collector/pumped/with water storage.
Integrated space heating and hot-water heating.

Building: New/single-family residence/3400 ft².

System: New/integrated space heating and hot-water heating/pumped/with water storage/radiant heating system in floor slab. Also passive-type system utilizing south-facing windows and interior thermal mass. Designed by Berkeley Solar Group.

Collector: 400 ft²/water-circulating flat plate/single glazing of Tedlar-coated fiberglass/copper Olin Brass Roll-Bond absorber plates used for collector in free-standing unit attached to fence on south side of house. Additional passive heating through 400 ft² of double-glazed south-facing windows.

Storage: 1100-gal concrete tank. Separate 100-gal tank for domestic hot-water with thermosiphon coil in main storage tank. Interior masonry partition wall adds thermal mass (estimated capacity of 100,000 Btu) for passive system storage.

Auxiliary: Electric baseboard heater, woodstove.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance: Not completed.

Additional Info: Heat delivery via radiant slab.

Source(s): Berkeley Solar Group, Berkeley, CA.

0 0 0 0 4 5 0 / 3 4 5
Santa Clara Community Recreation Center/Santa Clara/Solar space heating and cooling (\$436,000) early 1976

New construction/recreation center/contractor built/gas backup.
Roof-mounted flat-plate collectors/pumped/water circulating/with water storage.

Building: New*/recreation center/27,000 ft². Walls are 8-in concrete, no additional insulation.

System: New*/space heating and cooling/flat-plate collector/water circulating. Rooms heated by fan-coil system.

Collector: 6500 ft²/pumped/circulating fluid is water solution with 10% propylene glycol/flat-plate collector/double glazed. Absorber plates are copper Olin Brass Roll-Bond panels with selective black surface coating. Collector panels slope 18-deg from horizontal.

Storage: 10,000-gal cylindrical steel hot-water tank, insulated with plastic foam and located underground.

Auxiliary: Heating: 1,200,000 Btu/hr gas-fired boiler
Cooling: Two 25-ton Arkla LiBr absorption chillers, powered by gas boiler.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$436,000 (heating and cooling)

Performance: Heating: 84% predicted. Carry over of three days predicted.
Cooling: 65% predicted.

Additional Info: *New building, but decision to install solar system was made after building was basically designed.
\$101,000 feasibility study included.
Cooling: two 25-ton Arkla LiBr absorption chillers provide cooling, powered by hot water from solar on auxiliary systems.
50,000 gallon cylindrical steel chilled water storage tank, insulated with foam and located underground. 65% performance predicted.

Source(s):

Shurcliff (Ref. 2)

Scotty's Castle/Death Valley/Solar heating and solar hot water heating (\$) 1929

New construction (1929)/Residence/backup not specified.
Tube-on-plate/flat-plate collector/water circulating/with water storage.

Building: 2½-story residence.

System: New (1929) HWH and SH/flat-plate collector/water circulating, with water storage. Building designed by M. Alexander McNeilledge.

Collector: Included (per unconfirmed report) two arrays: one high above ground and one close to ground. Each included many parallel, black-painted, 3/4-in diameter pipes behind glass.

Storage: Large reservoir of water.

Auxiliary:

Cost: Solar: Collector: Storage: Aux./Other:

Materials
Labor
Total

Performance:

Additional Info: System probably of type on pp. 55-9 in Ref. 1:
F. A. Brooks, Solar Energy and Its Use for Heating Water in California, Bulletin 602, November 1936, College of Agriculture, University of California, Berkeley, California

Source(s): Shurcliff (Ref. 2)

Self-Help Enterprises/Visalia/Solar space heating and cooling (\$4000) late 1976.

New construction/single-family residences (5)/owner and contractor built.
Passive-type system/Skytherm design/integrated collection and storage/
roof-top water bags/with moveable insulation.

Building: New/single-family residences (5)/1200 ft². Part of new 45-unit tract of housing.

System: New/space heating and cooling/passive-type system (Skytherm)/ integrated collection and storage utilizing water-filled plastic bags on roof with moveable insulated covers/metal roof acts as ceiling, radiating or absorbing heat from interior. System designed by Harold Hay.

Collector: 1200 ft²/passive-type/water-filled plastic bags on roof/with moveable insulated panels above.

Storage: Water-filled plastic bags on roof/12-in depth.

Auxiliary:

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$4000*

Performance: Performance of Hay (Skytherm) system has been extensively analyzed.

Additional Info: *Not yet constructed. Will be owner and contractor built. Estimate is difference between cost of solar houses and conventional counterparts in the same tract. For operation of system, see Ref. 2.

Source(s): Bill French (Self-Help Enterprises, Visalia, CA)

SHWD/Winters/Solar space heating and cooling (\$4000) April 1975

New construction/single-family residence/contractor built/gas and wood backup. Passive-type system/roof-mounted, water-filled tanks with movable, insulated, reflective lids/south-facing with insulated shutters/slab floor and water-filled drums.

Building: New/single-family residence/1250 ft²/exposed concrete floor slab/open interior plan (walls don't go to the ceiling, except in bedroom and two bathrooms)/galvanized sheet metal roof/all windows have insulated shutters. Total cost \$27,000.

System: Passive-type using both roof-mounted, open metal tanks containing water-filled plastic bags with movable, insulated, reflective lids, and south-facing windows with insulated shutters. Slab floor plus water-filled steel drums for storage. System designed by Living Systems, Winters, CA.

Collector: 400 ft²/passive-type/galvanized steel roof-mounted open tanks containing 300-ft³ of water (7 tons) in 9-in deep plastic bags/covered by 6 insulated, reflective (aluminum foil on underside) lids, each 8 ft x 8 ft/raised by hydraulic ram. South-facing windows/with sliding interior shutters (Styrofoam insulated) or hinged, folded interior shutters (fiberglass insulated).

Storage: Water-filled plastic bags/300 ft³/in roof-mounted open tanks. Concrete floor slab. Twelve 55-gal water-filled steel drums.

Auxiliary: Gas wall heater (50,000 Btu)/small wood-burning heater in bedroom/30-in Franklin fireplace. No auxiliary for cooling.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$4000 \$1000 (shutters and drums)

Performance: Gas wall heater and wood-burning heater never used. Franklin fireplace used occasionally for brief periods. Estimate 95% solar heated and cooled.

Additional Info: Winter: lids open during day/sun warms water in tanks/lids closed at night to retain heat/bottom of tanks is exposed to interior, acting as part of ceiling/heat radiates to interior. Summer: operation reversed/lids open during night/water cooled by night air/lids closed during day/cool bottom of tanks absorbs heat from interior. Metal roof reflects sun in summer or directs additional sunlight onto reflective underside of lids in winter.

Source(s): Owner; John Hammond (Living Systems, Winters, CA)

SMT Residence/Aptos/Solar hot-water heating (\$2060) July 1975

Retrofit/single-family residence/contractor built/electric backup.
Flat-plate collector/pumped/water circulating/with water storage.

Building: Retrofit/single-family residence/3000 ft² (approx.)

System: Retrofit/HWH/flat-plate collector/water circulating/pumped/
with water storage. System designed and constructed by Berkeley
Solar Group.

Collector: 56 ft²/water-circulating flat plate/single glazing of Tedlar
coated fiberglas. Collector consists of copper Olin Roll-Bond
absorber plates in shop-fabricated insulated wood frame.

Storage: 100-gal converted gas water-heater tank.

Auxiliary: Electric hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$1260			
Labor	\$ 800			
Total	\$2060			

Performance: To be instrumented by PG&E.

Additional Info:

Source(s): Berkeley Solar Group, Berkeley, CA.

SPHS/Berkeley/Solar hot-water heating (\$1200) June 1976

New construction/single-family residence/contractor built/electric backup. Tube-on-plate flat-plate collector.

Building: New/single-family residence/2500 ft²/three bedrooms, two baths, living room, study, dining room, kitchen.

System: New/HWH/flat-plate collector/pumped/with water storage. Designed by Gary Gerber.

Collector: 60 ft²/copper tube on aluminum plate, Filon glazing, urethane insulation. Mounted on 50-deg roof, south-facing.

Storage: 120-gal Solaraide storage

Auxiliary: Electric: 6000-watt element in storage tank.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 700	\$275	\$225	\$200
Labor	\$ 500	\$200	-	\$300
Total	\$1200	\$475	\$225	\$500

Performance:

Additional Info:

Source(s): Gary Gerber (Interactive Resources, Inc., Pt. Richmond, CA)

TRK/Santa Rosa/Solar hot-water heating (\$1200) Summer 1976

Retrofit/single-family residence/contractor built/electric backup.
 Integrated system installed with new swimming pool to provide
 pool heating, space heating, hot-water heating, and spa heating.
 Uses water-to-air heat pump from swimming pool.

Building: Existing residence.

System: Retrofit/HWH/flat-plate collector/pumped water circulating
 with water storage. System designed by Interactive
 Resources, Inc.

Collector: 50 ft²/water-circulating flat plate/single glass glazing
 Raypack collector.

Storage: 120-gal hot-water tank with bottom element disconnected.

Auxiliary: 120-gal electric HWH.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$1200

Performance:

Additional Info:

Source(s): Dale Sartor (Interactive Resources, Inc., Pt. Richmond, CA)

TRK/Santa Rosa/Solar space heating (\$) Summer 1976.

Retrofit/single-family residence/contractor built/electric backup.
Integrated system installed with new swimming pool to provide
pool heating, space heating, hot-water heating, and spa heating.
Uses water-to-air heat pump from swimming pool.

Building: Existing residence.

System: Retrofit/space heating/flat-plate collector/pumped water
circulating to swimming pool. Heat pump transfers heat
from swimming pool to house. System designed by
Interactive Resources, Inc.

Collector: 440 ft²/flat-plate collector/unglazed. Absorber plate is
tube-on-plate (Raypack).

Storage: Swimming pool (covered in winter).

Auxiliary: Electric heat pump (forced-air).

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total

Performance:

Additional Info: Forced-air heat pump system using water-to-air
heat pump. Warm water fed from solar-heated
swimming pool (covered during winter).

Source(s): Dale Sartor (Interactive Resources, Inc. Pt. Richmond, CA)

WRD Residence/Davis/Solar hot-water heating and space heating (\$3510) July 1974

New construction/single-family residence/contractor built/gas backup. Roof-mounted sandwich-type flat-plate collector/thermosiphon/water circulating/with water storage. Also passive-type system (windows with moveable insulation). Integrated space heating and hot-water heating.

Building: New/single-family residence/one story/1200 ft²/three bedrooms and one bath/wood-frame construction on 6-in concrete slab. 175 ft² of south-facing windows (80% of south wall). Oriented 12° E of S. Built by M. Corbett.

System: New/HWH and SH/sandwich-type flat-plate collector/water circulating/thermosiphon/with water storage. Heat distributed by radiant heating system in concrete floor. System designed by Natural Heating System, Davis, CA. Additional space heating provided by passive system (175 ft² of south-facing windows with moveable Styrofoam insulation 1-in thick).

Collector: 200 ft²/water-circulating flat plate/double glazing of glass. Absorber plate is 18-gauge galvanized steel sandwich panel formed, riveted, and soldered together; flat black paint/on 60-deg tilt/manifolded to storage tank with 2-in CPVC and heater hose connections. Collector manufactured by Natural Heating Systems, Davis, CA.

Storage: 200-gal galvanized steel water tank in attic. Additional storage provided by concrete slab (radiant floor) insulated from ground by urethane foam. 20-gal tank inside main storage tank acts as heat exchanger and storage for domestic hot-water system.

Auxiliary: Franklin wood stove and gas wall heater; gas hot-water heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$2474.20 (for HWH and space heating)			
Labor	\$1036.55 (for HWH and space heating)			
Total	\$3510.75 (for HWH and space heating)			

Performance: 70% estimated; 80% measured

Additional Info: HWH system can operate as preheater or sole supplier of domestic hot water. Main storage tank is 1 ft above top of collector so backsiphons to prevent freezing. 1/12-hp pump sends hot water from storage to slab radiant system (6 zones) of 1/2-in copper pipe.

Source(s): Dave Springer and John Hofacre (Natural Heating Systems, Davis, CA); Shurcliff (Ref. 2)

WTMN/Sacramento/Solar space heating, cooling, and hot-water heating
(\$6000) January 1976

Retrofit/single-family residence/contractor built/gas backup. Roof mounted/flat-plate collector/pumped/water circulating/with water storage. Integrated space heating, cooling, and hot-water heating system.

Building: Retrofit/single-family residence/2100 ft². Four bedrooms, three baths, two-story residence. Ceiling insulation R-19, walls R-7-10. Roof slope faces east. Separate support structures for collectors built on sloping roof of house and on flat roof of patio.

System: Retrofit/SH and HWH/flat-plate collector/water circulating/pumped/with water storage. System integrated with forced-air heating system. System designed by Alten Associates, Santa Clara, CA.

Collector: 381 ft²/water circulating/flat-plate collector/double Tedlar glazing. Absorber is Olin Brass Company Roll-Bond copper plate. Collectors mounted on separate support structures built on sloping roof of house and flat roof of patio, at 42-deg and 45-deg tilts, respectively.

Storage: Two 1000-gal steel tanks*, insulation, located in garage.

Auxiliary: Gas furnace/forced-air heating system; gas hot-water heater.

Cost: Solar: Collector: Storage: Aux./Other:

Materials

Labor

Total \$6000

Performance: 80-90% (est.). Monitoring: tank temperature, panel temperature, ambient temperature, house temperature, and wind velocity (planned).

Additional Info: *System financed by credit union on 15-yr loan (\$67.50/month) Tanks open to atmosphere. 1/8-hp pump fills collector circuit/atmospheric pressure holds water up, pump merely overcoming friction. Air bled into top of system to drain. Copper tube and aluminum fin heat exchanger delivers heat to conventional ducting system.

Source(s): Owner

WXD/San Francisco/Solar hot-water heating (\$2800) Spring 1975

Retrofit/single-family residence/owner built (except collector box)/electric backup. Tube-and-plate flat plate collector/water circulating/pumped/water storage.

Building: Single-family residence/3 stories. Corner building with flat roof (collectors mounted on roof.)

System: Retrofit/HWH/pumped water-circulating with water storage.

Collector: 70 ft²/water-circulating flat plate/single glazing of 1/4-in plexiglass. Collector purchased from Sol-Therm Corp. (Israel). Collector mounted at 45-degree angle on roof.

Storage: 160 gallons (two 80-gallon glass-lined steel tanks, located in basement).

Auxiliary: Electric hotwater heater (80 gallons).

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 2800	\$ 950	\$ 500	\$ 185
Labor	-	-	-	-
Total	\$ 2800	\$ 960	\$ 500	\$ 186

Performance: Estimated 35-40% in December and January, 60-80% during remainder of the year. (Owner saved utility bills).

Additional Info: System located in a sunny portion of San Francisco. Pipe run from roof (collectors) to basement (storage) is 160 feet. Collectors were \$750 plus \$200 shipping.

Source(s): Owner

XFLNS-A/Occidental/Solar space heating and cooling (\$200) September 1976

New/cabin/student-built/electric backup. Passive-type system/forced-air circulating (fan) with thermal storage of river rock plus slab floor.

Building: New/student cabin/260 ft² including loft. 1½ story wood-frame construction, slab floor over rock bed storage. Faces due south. Whole building cost \$2500.

System: New/passive-type air system. Air heated by sunlight passing through south-facing windows is circulated through rock bed below slab floor by means of a small fan. System designed by Peter Calthorpe.

Collector: 90-ft² vertical south wall (single glass glazing) plus 15-ft² skylight on south-facing roof. Vertical south wall has movable insulation (folding shutter of R-9 urethane foam insulation).

Storage: 196-ft² slab floor (14 ft x 14 ft x 4 in) plus 286 cubic ft of river rock (under slab floor).

Auxiliary: Electric resistance heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 200	-	\$ 150	\$ 50
Labor	-	-	-	-
Total	\$ 200	-	\$ 150	\$ 50

Performance: Estimate 90% - 95% heating and cooling needs. To be instrumented for comparison study.

Additional Info: Part of passive solar heating comparison study: each unit has 5,000 BTU/degree day heat loss, and rock storage capacity of 12,000 BTU °F or approximately 3 days storage.

Source(s): Peter Calthorpe, Farallones Institute, 15290 Coleman Valley Rd., Occidental, CA 95465.

XFLNS-B1/Occidental/Solar space heating and cooling (\$350) September 1976

New/cabin/student-built/electric backup. Passive type system/forced-air circulating (fan) with thermal storage of river rock plus slab floor over rock. Also roof pond with moveable insulating lid and reflector.

Building: New/student cabin/260 ft² including loft. 1½ story wood-frame construction, slab floor over rock-bed storage. Faces due south. Whole building cost was \$2500.

System: New/passive-type air system plus passive-type water system. (Roof pond). Air heated by sunlight passing through south-facing windows is circulated through rock bed below slab floor. Roof pond, heated during day is insulated by closing lid at night. Heat radiates through ferrocement roof into living space. Process reversed for cooling. System designed by Peter Calthorpe.

Collector: 60-ft² vertical south wall (single glass glazing), plus 60-ft² roof pond on roof deck. Pond consists of black plastic water bed (about 8-in deep) with movable insulating lid. Lid is foam insulation surfaced with reflective foil.

Storage: 196-ft² slab floor (14 ft x 14 ft x 14-in) plus 286 cubic feet of river rock under slab floor plus 2800 lbs of water in roof pond.

Auxiliary: Electric resistance heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 350	\$ 150*	\$ 150	\$ 50
Labor				
Total	\$ 350	\$ 150*	\$ 150	\$ 50

Performance: Estimate 90%-95% of heating and cooling needs. To be instrumented for detailed study.

Additional Info: Part of passive solar heating comparison study: each unit has 5,000 BTU/degree day heat loss, and rock storage capacity of 12,000 BTU/°F of storage in roof pond. *Cost of roof pond (ferrocement, waterbed and cover)

Source(s): Peter Calthorpe, Farallones Institute, 15290 Coleman Valley Rd., Occidental, CA 95465

New/cabin/student-built/electric backup. Passive-type system with south glass, and slab floor plus rock-bed storage, air-circulating with small fan. Also flat-plate (air) collector.

Building: New/student cabin/196 ft² plus small sleeping loft. 1½-story wood-frame construction, slab floor over rock bed storage. Faces due south. Whole building cost was \$2600 (materials only).

System: New/passive-type air system. Air heated by sunlight passing through south-facing windows and air heated in flat plate collector is circulated through rock bed below slab floor, recirculated into room from rock bed to heat living space. System designed by Peter Calthorpe.

Collector: 60 ft² vertical south wall (single glass glazing), plus 70 ft² air-type flat plate collector single glass glazing, black expanded metal lath.

Storage: 196-ft² slab floor (14 ft x 14 ft x 4-in) plus 286 cubic ft of river rock (under slab floor).

Auxiliary: Electric resistance heater.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 350	\$ 150*	\$ 150	\$ 50
Labor	-			
Total	\$ 350	\$ 150*	\$ 150	\$ 50

Performance: Estimate 90% - 95% heating and cooling needs. To be instrumented for comparison study.

Additional Info: Part of passive solar heating comparison study: each unit has 5,000 BTU/degree day heat loss, and rock storage capacity of 12,000 BTU/°F, or approximately 3 days storage. Cost of air-type flat plate collector.

Source(s): Peter Calthorpe, Farallones Institute, 15290 Coleman Valley Rd., Occidental, CA 95465

XFLNS-D/Occidental/Solar space heating and cooling (\$200) September 1976

New/cabin/student-built/ electric backup. Passive type system with with greenhouse collector. Heated air circulated into house and rock bed storage under slab by a small fan.

Building: New/student cabin/324 ft² plus 140 ft² sleeping loft and 80 ft² greenhouse.

System: New/passive type system/air-circulating (small fan) with rock and slab floor storage. Air heated in greenhouse rises to roof and is circulated down from roof area through duct on north wall, into rock bed. Air circulated through rocks to heat cabin. System designed by Peter Calthorpe.

Collector: Greenhouse on south side of house. Single glass glazing.

Storage: 324 ft² slab floor (18 ft x 18 ft x 4-in) plus 510 cubic ft of river rock (under slab floor).

Auxiliary: No auxiliary, or small wood stove as auxiliary.

Cost:	Solar:	Collector:	Storage:	Aux./Other:
Materials	\$ 200	greenhouse	\$ 150	\$ 50
Labor	—			
Total	\$ 200	greenhouse	\$ 150	\$ 50

Performance: Estimate 90% - 95% heating and cooling needs. To be instrumented for comparison study.

Additional Info: Part of passive solar heating comparison study.

Source(s): Peter Calthorpe, Farallones Institute, 15290 Coleman Valley Rd. Occidental, CA 95465

XMDJ/Mill Valley/solar space heating/(\$10) October 1976

Retrofit/single-family residence/owner built/gas backup.
Passive-type system using water-filled beer bottles in south wall, with insulating door.

Building: Retrofit/single-family residence/1000 ft².

System: Passive-type system/water/using vertical south-facing bottlewall/
single glass glazing/beer-bottles. System designed by M. Dean Jones.

Collector: 42 ft²/single glass glazing/water/using vertical south-facing bottlewall
studs of existing wall. Moveable insulation/foil backed foam/
reflector.

Storage: Water-filled beer bottles.

Auxiliary: Gas forced-air furnace and fireplace.

Cost:	Solar	Collector:	Storage:	Aux./Other:
Materials	\$10			
Labor				
Total	\$10*			

Performance: Estimate 20%-25% of heating needs.

Additional Info: * All materials recycled.
Two other houses under construction.

Source(s): M. Dean Jones, Architect, P.O. Box 377, Tiburon, California, 94920.

Building:

System:

Collector:

Storage:

Auxiliary:

Cost:

Solar:

Collector:

Storage:

Aux./Other:

Materials

Labor

Total

Performance:

Additional Info:

Source(s):

Building:

System:

Collector:

Storage:

Auxiliary:

Cost:

Solar:

Collector:

Storage:

Aux./Other

Materials

Labor

Total

Performance:

Additional Info:

Source(s):

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